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Science 20

MODULES 1-8

Learning Facilitator's Manual

Distance Learning

Alberta EDUCATION

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Science 20

LEARNING FACILITATOR'S MANUAL

Alberta
EDUCATION

NOTE: This Science 20 Learning Facilitator's Manual contains answers to teacher-assessed assignments and the final test; therefore, it should be kept secure by the teacher. Students should not have access to these assignments or the final test until they are assigned in a supervised situation. The answers should be stored securely by the teacher at all times.

This document is intended for	
Students	
Teachers (Science 20)	✓
Administrators	
Parents	
General Public	
Other	

Science 20
Learning Facilitator's Manual
Modules 1-8
Alberta Distance Learning Centre
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Teachers

Register with the Alberta Distance Learning Centre

The Alberta Distance Learning Centre is dedicated to upgrading and continually improving your Learning Facilitator's Manual so that it accurately reflects any necessary revisions we have had to make in the student module booklets, assignment booklets, or the sample final test. The types of revisions that will be made are those that make the course more accurate, current, or more effective.

The ADLC will send you the **latest enhancements or minor upgrades** for your Learning Facilitator's Manual if you return the following registration card to: Alberta Distance Learning Centre, Box 4000, Barrhead, Alberta, T0G 2P0, Attention: Instructional Design and Development.

ADLC Learning Facilitator's Manual
Registration Card

First Name	Surname
School Name	School Phone Number
School Address	
City	Postal Code
Course Title	Approximate Date of Purchase

You can help ensure that distance learning courseware is of top quality by letting us know of areas that need to be adjusted. Call the Alberta Distance Learning Centre free of charge by using the RITE line and ask for the Editing Unit. Also, a teacher questionnaire has been included at the back of most Learning Facilitator's Manuals. Please take a moment to fill this out.

We look forward to hearing from you!

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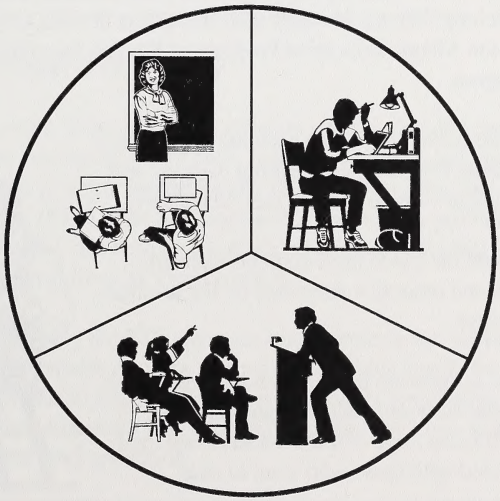
Introduction

A survey of these course materials will confirm that this new learning package has been specially designed for many kinds of teachers working in a variety of situations.

Which Category Do You Fit?

- ❑ Small Schools Teacher
  - ❑ inexperienced
  - ❑ experienced, but in other subject areas
  - ❑ experienced in teaching Science 20, but wanting to try a different approach
- ❑ Distance Learning Teacher
  - ❑ travelling to schools within the jurisdiction
  - ❑ using facsimile and teleconferences to teach students within the area
- ❑ Larger Schools Teacher
  - ❑ inexperienced
  - ❑ experienced in teaching Science 20, but wanting to try a different approach



Because these materials have been created by experienced classroom teachers and distance learning specialists, they have many advantages for students and teachers regardless of their situations.

Advantages for Students

- incorporates a strong learner-centred philosophy
- promotes such qualities in the learner as autonomy, independence, and flexibility
- is developed through media which suit the needs and circumstances of the learner
- reflects the experiential background of Alberta students
- opens up opportunities by overcoming barriers that result from geographical location
- promotes individualized learning, allowing learners to work at their own pace

Advantages for Teachers

- allows teachers maximum teaching time and minimizes preparation time
- includes different routes through the materials to suit different learners
- incorporates a wide range of teaching strategies, in particular those using independent and individual learning
- delivers curriculum designed by education specialists that reflects the Alberta Education Program of Studies with an emphasis on Canadian content
- provides learning materials which are upwardly compatible with advanced educational technology

Does it sound like something you could use?

This Learning Facilitator's Manual begins with an overview of the current Alberta Education Program of Studies for Science 20. This summary is included for inexperienced teachers or those teachers who have found themselves teaching Science 20 when their training is in other subject areas. This brief summary is not meant to replace the Alberta Education Program of Studies, but rather to help teachers confirm the highlights of the program.

Other parts of this introduction have also been included to help teachers become familiar with this new learning package and determine how they might want to use it in their classroom.

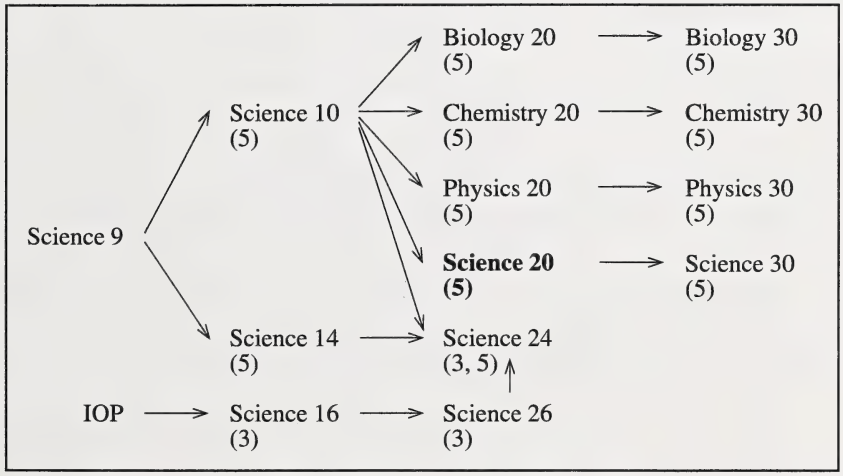
Beyond the introduction the guide itself contains answers, models, explanations, and other tips generated by the teachers who authored this course.

The module booklets, assignment booklets, and LFMs are the products of experienced classroom teachers and distance learning specialists. It is the hope of these teachers that their experience can be shared with those who want to take advantage of it.

Overview of the Program of Studies

The Science 10/20/30 program is the result of Alberta Education's Secondary Education Review of 1985. The policy set forward by this review established new requirements for high school graduation. High school students are now required to complete a minimum of two science courses (8 credits) to obtain a General High School Diploma and three science courses (15 credits) to obtain an Advanced High School Diploma. The Science 10/20/30 program was designed to provide a well-rounded science education for those students who choose to take the minimum number of credits in science for the Advanced High School Diploma.

The following diagram illustrates the various course sequences in the Senior High Science Program. Credit values are provided in brackets beneath each of the courses shown on the diagram. Notice that Science 20 follows in sequence from Science 10 and should provide the foundation necessary to proceed to Science 30.



[1]

Science, Technology, and Society

The 1985 policy statement, *Secondary Education in Alberta*, also directed the new high school science program to emphasize the application of basic scientific concepts and principles in the real world. The new high school science program has achieved this by emphasizing the interrelationship of science, technology, and society, (STS). The STS approach is intended to provide Alberta students with a more balanced science education, one with an emphasis on science in the real world, rather than focussing on a body of knowledge isolated from its social context.

The teaching of science using the STS approach must centre on the development of scientifically literate and responsible citizens capable of using scientific knowledge wisely for the good of all members of society. The STS approach to science challenges students by developing scientific literacy through experimentation and investigation. This approach motivates students to learn more about science and to apply what they learn to other situations.

[1] Senior High Science Teacher Resource Manual, Curriculum Branch, 1992.

Technology is often the main point of contact individuals have with science. High school students are intrigued by the ever-developing gadgets and processes that characterize our age. There is therefore a tremendous opportunity, when dealing with the relationship between science and technology, to make the subject come alive. Science deals with gravity and friction, but technology gives us the wheel. While science asks "why?", technology asks "how?". Science is aimed at increasing human understanding and ability to explain nature. Technology is aimed at developing devices or processes that have practical purposes.

Science and technology affect every aspect of the daily life of Canadians. Both science and technology are involved in areas as diverse as communications, travel, agriculture, and waste management. But what is science and what is technology? Are they the same or are they different? How do science and technology affect society? How does society control science and technology? If students are to become enlightened, contributing citizens in a constantly changing society they will need to know the answers to these questions.

Scientific Literacy

Scientific literacy is an important goal of secondary school education, as it provides a means for asking and answering some very important questions.

A scientifically literate person has the following characteristics:

- demonstrates a working knowledge and practical understanding of the sciences
- has the ability to evaluate scientific evidence
- understands the processes by which scientific knowledge is developed and can adapt those processes for personal use
- applies science concepts, theories and processes to the investigation of everyday problems
- understands the relationship between science and technology
- demonstrates awareness of how science and technology can function responsibly in a social context
- recognizes the limitations as well as the usefulness of science and technology in advancing human welfare
- demonstrates a continuing interest in science and technology.[1]

An Integrated Science Curriculum

The Science 10/20/30 program uses an integrated approach to science education that is organized around themes which transcend the artificial boundaries of traditional science disciplines. This integrated approach more accurately reflects the current nature of science, with major advances now occurring in interdisciplinary areas such as geophysics, astrophysics, biophysics, and biochemistry. The integrated science approach is built on the premise that the fundamental concepts, skills, and attitudes of science are common to all scientific disciplines.

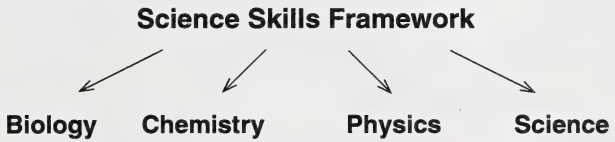
The Science 10/20/30 program allows teachers to explore many areas of science with their students instead of being restricted to one particular discipline.

[1] Senior High Science Teacher Resource Manual, Curriculum Branch, 1992.

The fundamental or key concepts in Science 20 are change, diversity, equilibrium, matter, energy, and systems. These conceptual themes provide teachers with a means of showing the connections among scientific disciplines to students. The conceptual themes also provide a frameowrk that students can use to see how individual sections of the course relate to the big ideas of science. The common theme in Science 20 is change.

The skills and attitudes developed in the Science 10/20/30 program also enhance the integration of themes. Students should come to realize that there are scientific process skills which are common to all disciplines. Skills such as questioning, hypothesizing, designing experiments, and gathering, processing, and interpreting data are universal in their importance to science and scientific research.

Teaching science using an integrated approach means reducing the sheer amount of material covered, fostering a scientific way of thinking, and paying more attention to the interactions of science, technology, and society.



The development of the new science programs has necessitated a review of assessment methods. Since the growth of science problem-solving skills in students is a priority of the science curricula, assessment methods must reflect this emphasis.

The document, *A Model for the Assessment and Evaluation of Scientific Problem-Solving Skills*, Draft, June 8, 1992, has direct implications for ADLC students and school students using distance learning materials. The following proposal attempts to incorporate the evaluation scheme into distance learning materials.

There are six categories in which the science skills of students will be assessed:

A. Initiating and Planning
B. Collecting and Recording
C. Organizing and Communicating
D. Analysing
E. Connecting, Synthesizing, and Integrating
F. Evaluating the process or Outcomes

Each category will be assessed according to a level scheme as discussed in the document. This scheme will need to be explained to students. Each course will have a standard explanation outlining the assessment model in Module 1.

Each course will have a science skills spreadsheet that allows students to record their progress in completing the science skills component of selected assignment questions throughout the course. The Science 20 spreadsheet is in the Appendix of Module 1. Science skills could be evaluated in the context of a lab investigation, a research project, a case study, or a group project. The framework for scientific problem-solving skills is explained in the Appendix of Module 1.

Each course will have to ensure that students have opportunities to be evaluated in each of the skills. In addition, students will need to be given formative practice at developing the skills throughout the activities and investigations. **Note:** The skill level indicated by the teacher to the student in the assignment questions is **NOT** reflected in the mark of the questions.

The evaluation of these skills will be ongoing throughout each science course. Students will be encouraged to do self-evaluation as well as a summative evaluation that focuses on growth and improvement.

Self-Evaluation

- When students do the activities in their module booklets, the science skills icon will reinforce which skills are being practiced. Students will be encouraged to reflect on their skill level.

- When students complete a question in the assignment that focuses on a science skill, they will be asked to evaluate the level of their response before it is submitted for grading. The teacher marking the assignment will then supply the student with his or her evaluation of the response along with a concise explanation if the level is different from what the student suggested.

- This area of self-evaluation will be explored further and enhanced for the 30-level courses.

- Self-evaluation concludes by students analysing their own progress as displayed on the spreadsheet. A mark will be given for this spreadsheet upon its completion. Each time their assignments are returned, the students are expected to transfer both the teacher level assessment and their own level assessment to the spreadsheet.

Summative Evaluation

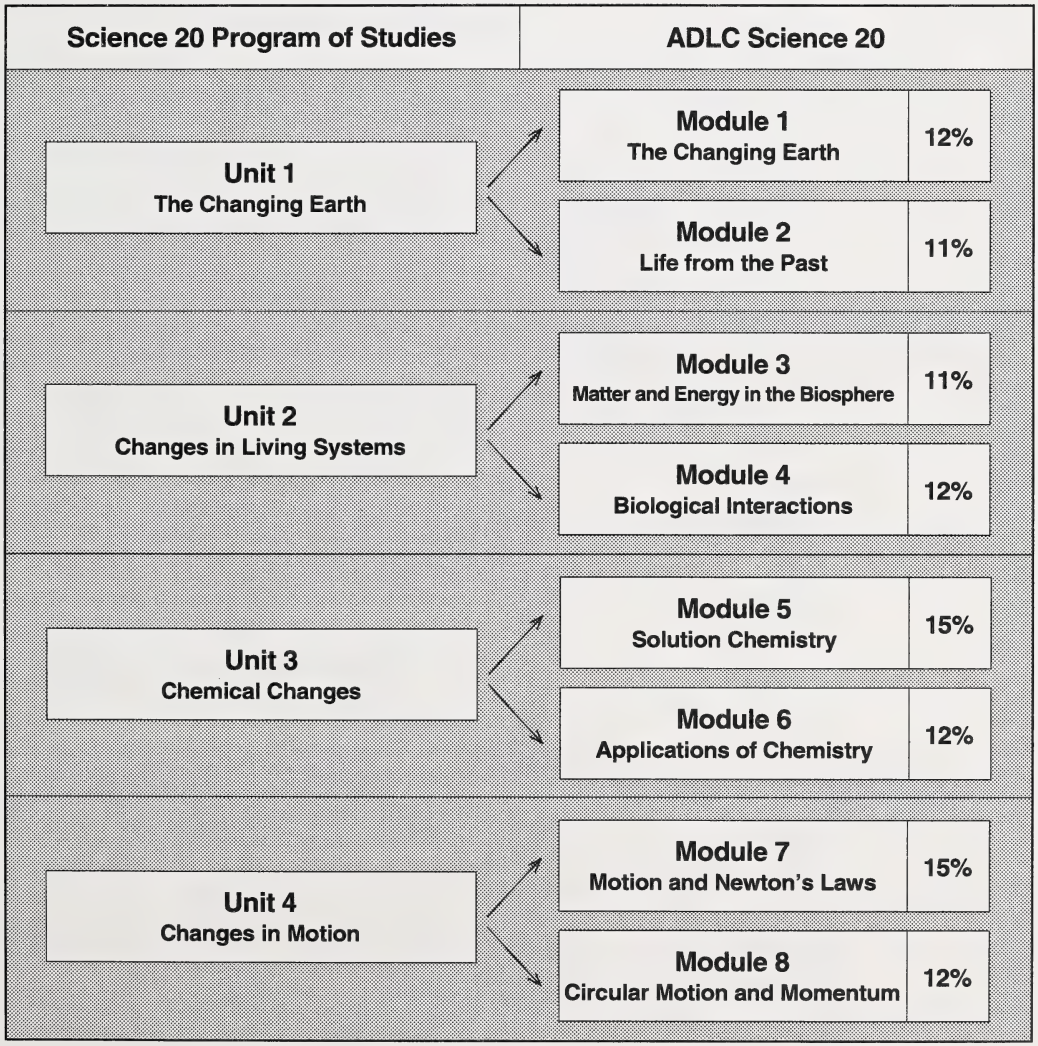
- The level of a student's performance will be determined by the teacher throughout the course. As shown in Self-Evaluation, the level of performance for a particular science skill or set of skills will be assessed in the assignment questions that have been "flagged."

- The students will carefully track their progress throughout the course by recording their level and the teacher's level of assessment of achievement on their spreadsheet. The teacher will keep an on-going record of all teacher level assessment.

Overview of Science 20

The ADLC Science 20 course is made up of eight modules. Modules 1 and 2 involve the study of the Earth's physical features and past life history. Modules 3 and 4 involve the study of life and its interaction with the Earth. Modules 5 and 6 involve the study of solutions as well as how chemistry is used for everyday things. Modules 7 and 8 investigate motion, both on Earth and in space.

The sequence of modules follows the Science 20 program of studies as outlined by the Curriculum Branch, Department of Education. The following graphic illustrates the relationship between the program of studies and the Science 20 program as produced by the Alberta Distance Learning Centre. The recommended percentage of available instructional time is also given for each module.

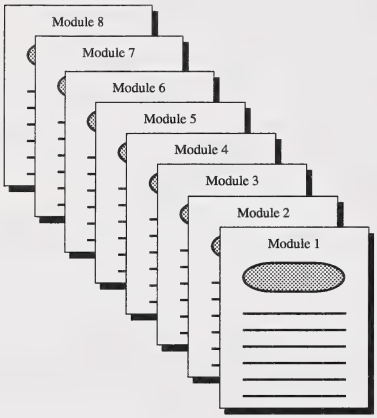


Structure of the Learning Package

Basic Design

This new learning package involves many other components in addition to the Learning Facilitator's Manual.

Modules



The print components involve many booklets called modules. These modules contain guided activities that instruct students in a relevant, realistic setting.

The modules have been specially designed to promote such qualities in the learner as autonomy, independence, and flexibility. Writers have incorporated such teaching strategies as working from the concrete to the abstract, linking the old to the new, getting students actively involved, and using advance, intermediate, and post organizers. Many other techniques enable learners to learn on their own for at least some of the time.

Contents
Overview Evaluation
Section 1 Activity 1 Activity 2 etc.
Section 2 Activity 1 Activity 2 etc.
Section 3 Activity 1 Activity 2 etc.
Section 4 Activity 1 Activity 2 etc.
Module Summary

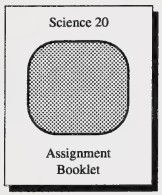
The structure of the module booklets follows a systematic design. Each module begins with a detailed table of contents which shows the students all the main steps. It acts as an organizer for students. The overview introduces the module topic or theme. A graphic representation has been included to help visual learners and poor readers. The introduction also states the weightings of each assignment.

The body of the module is made up of two or more closely related sections. Each section contains student activities that develop skills and knowledge centred around a theme.

The activities may involve print, audio, video, computer, or laser videodisc formats. At times the student and the learning facilitator are allowed to choose the activity that best suits the student's needs and interests. Other activities such as the Extra Help and Enrichment are optional pathways. This flexibility caters to each student's personal situation.

The summary focuses on the skills and strategies that the student has learned.

Assignment Booklet



Accompanying each module is an assignment booklet. The activities in these booklets can be used for formative and for summative assessments. The students should complete these assignment booklets when they have thoroughly reviewed the module materials. The assignment booklets have been designed for classroom use, for faxing, or for mailing. **If the booklets are not being mailed, you should remove the outside cover.**

Media

VIDEOCASSETTE

The package also includes references to media. There are activities that require students to view certain videos. These mandatory videos are listed on the following page. It is important that you acquire these videos as you are planning the course. In addition to the mandatory videos, optional videos have been mentioned at various points in the modules. A list of the optional videos is also included on the following page. More information about the videos can be found within the LFM.

Textbooks and Reference Books

This package requires students to use Visions 2, published by Gage, as their textbook. Additional references are indicated later in this manual.

Lab and Other Materials

The package includes references to lab materials. A list of necessary materials is included later in this manual.

Materials, Media, and Equipment

Mandatory Components

Equipment (Hardware)	Media	Materials
• VCR	• Mandatory Video List: (Science 20 Video 1) – The Birth of a Theory – Sedimentary Rocks, Earth Revealed Series – Geologic Time, Earth Revealed Series – Aspects of Ecology: Ecosystems (Science 20 Video 2) – Recycling: The Endless Circle – Global Warming: Hot Times Ahead – If You Build It – Acids and Bases – Electrochemistry: Electrochemical Cells – Electrochemistry: Electroplating – Force and Motion: Newton's Three Laws	• LFM for Science 20 • one complete set of module booklets (8) and assignment booklets (8) for each student • There is a final test.

Videocassettes used in the course may be available from the Learning Resources Distributing Centre or ACCESS Network. You may also wish to call your regional library service for more information.

Optional Components

Equipment (Hardware)	Media	Materials
• VCR	• Optional Video List: – Living With Earth: Part 1, Earth Revealed Series – Earth's Interior, Earth Revealed Series – Earthquakes, Earth Revealed Series – Plate Dynamics, Earth Revealed Series – Minerals: The Materials of the Earth – Volcanism, Earth Revealed Series – Petroleum: River of Energy – Organic Evolution: Darwin Naturally – Water: A Precious Resource – Fate of the Earth, Part 1: Geochemical Cycles – Ecology: Communities – Aspects of Ecology: Populations – Ecology: Succession – Electrochemistry: Corrosion – Mechanical Universe: Inertia	

Using This Learning Package in the Classroom

Conventional Classroom

Whether your classroom has desks in rows or tables in small groups, you may be most comfortable with a learning system that you can use with all your students in a paced style. In other words, you may want a package that will suit all of your students, so they can move through the materials as one group or several small groups. Because these materials contain different routes or pathways within each module, they can address various learning styles and preferences. The materials also include many choices within the activities to cater to different thinking levels and ability levels. Because of their versatility and flexibility, these materials can easily suit a conventional classroom.

Open-Learning Classroom

Open learning is the concept of opening up opportunities by overcoming barriers of time, pace, and place by giving the learners a package specially designed to enable them to learn on their own for at least some of the time.

Such a concept is not new. Many teachers can recite attempts to establish an individualized learning system as they recognized the importance of trying to personalize courseware to meet each individual student's needs. But these efforts often failed due to lack of time and lack of quality materials that conformed to Alberta specifications.

Due to advanced educational technology and improved Alberta-specific learning packages, a student-centred approach is now possible. Improved technology now allows us to provide support to learners individually, regardless of their pace or location. A teacher cannot be in twenty-eight places at one time offering guidance. However, media and a well-designed learning package can satisfy individual needs. Technology can also help provide an effective management system needed to track the students as they progress independently through the materials.

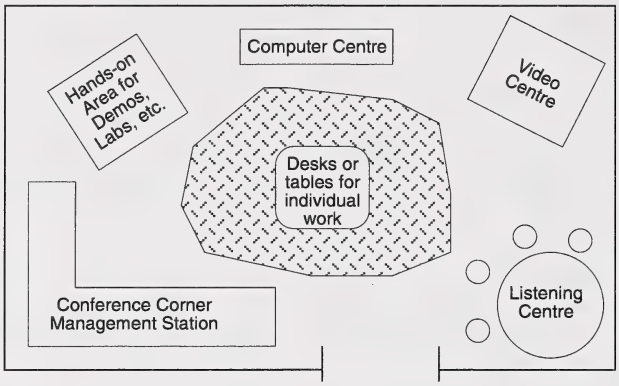
The key to a successful open-learning system depends on three vital elements: a learning package specially designed to enable students to learn effectively on their own for at least some of the time; various kinds of learner support; and a management system and style that ensures that the open-learning system runs smoothly.

The Key to a Successful Open-Learning System

Learning Package

The specially designed learning package needed for a successful open-learning system has been developed for you. The objectives teach current Alberta specifications using strategies designed for individualized instruction. As the learning facilitator, you need to be sure to have all the components in the learning package available to students as needed.

If adequate numbers of media are available to satisfy the demand, a centre can be established for specific media.



You may not have the luxury to have enough hardware to set up a permanent video or computer centre in your classroom. In that case, students should be encouraged to plan ahead. Perhaps every three to five days they should preview their materials and project when they would need a certain piece of media. This would allow you to group students, if necessary, or reserve media as required.

Support

Support is definitely a key element for successful learning, and when you're planning an individualized, non-paced program, you need to carefully plan when and how support will be given.

The materials contain a form of consistent support by providing immediate feedback for activities included in the module booklet. High school students have solutions, models, explanations, and guides included in the appendix of every module booklet. These are included so students can receive immediate feedback to clarify and reinforce their basic understanding before they move on to higher levels of thinking.

As the learning facilitator, you may be needed to offer more personal guidance to those students having difficulty, or you may need to reinforce the need for students to do these activities carefully before attempting the assignments in the assignment booklet.

The activities include choices and pathways. If a student is having difficulty, you may need to encourage that student to work on all the choices rather than one. This would provide additional instruction and practice in a variety of ways.

Another form of support is routine contact with each individual. This might be achieved with a biweekly conference scheduled by you, or as students reach a certain point (e.g., after each section is completed), they may be directed to come to the conference area.

Special counselling may be needed to help students through difficult stages. Praise and encouragement are important motivators, particularly for those students who are not used to working independently.

Direct teaching may be needed and scheduled at certain points in the program. This might involve small groups or a large group. It might be used to take advantage of something timely (e.g., election, eclipse, etc.), something prescheduled like the demonstration of a process, or something involving students in a hands-on, practical experience.

Support at a distance might include tutoring by phone, teleconferencing, faxing, or planned visits. These contacts are the lifeline between learners and distance education teachers, so a warm dialogue is essential.

Management

Good management of an open-learning system is essential to the success of the program. The following areas need action to ensure that the system runs smoothly:

- Scheduling, Distributing, and Managing Resources – As discussed earlier, this may require a need for centres or a system for students to project and reserve the necessary resources.

- Scheduling Students – Students and teachers should work together to establish goals, course completion timelines, and daily timelines. Although students may push to continue for long periods of time (e.g., all morning), teachers should discourage this. Concentration, retention, and motivation are improved by taking scheduled breaks.

- Monitoring Student Progress – You will need to record when modules are completed by each student. Your data might also include the projected date of completion if you are using a student contract approach.

Sample of a Student Progress Chart

Science 20		Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Final Test
Billy Adams	P									
	A									
Louise Despins	P									
	A									
Violet Klaissian	P									
	A									
P = Projected Completion Date A = Actual Completion Date										

The student could keep a personal log as well. Such tracking of data could be stored easily on a computer.

- Recording Student Assessments – You will need to record the marks awarded to each student for work completed in each module assignment booklet. The marks from these assignment booklets will contribute to a portion of the student's final mark. Other criteria may also be added (a special project, effort, attitude, etc.). Whatever the criteria, they should be made clear to all students at the beginning.

Sample of a Student Assessment Chart

Science 20	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Year's Average	Final Test	Final Mark
Billy Adams	**67**	**65**	**54**	**47**	**78**	**67**	**72**	**57**	**63**		
Louise Despins	**43**	**50**	**54**	**55**	**48**	**42**	**52**	**45**	**49**		
Violet Klaissian	**65**	**65**	**66**	**68**	**67**	**70**	**68**	**69**	**67**		

Letter grading could easily be substituted.

- Recording Effectiveness of System – Keep ongoing records of how the system is working. This will help you in future planning.

Sample of a System Assessment Chart

Module 1			
Date	Module Booklet	Assignment Booklet	Resources/Media

The Role of the Teacher in an Open-Learning Classroom

The teachers in a conventional classroom spend a lot of time talking to large groups of learners. The situation in open learning requires a different emphasis. Teachers will probably meet learners individually or in very small groups.

With this approach it is necessary to move beyond the idea of a passive learner depending largely on a continually supportive teacher. The teacher must aim to build the student's confidence, to stimulate the learner into self-reliance, and to guide the learner to take advantage of routes that are most meaningful and applicable to the learner.

These materials are student-centred, not teacher-centred. The teacher needs to facilitate learning by providing general support to the learner.

Evaluation

Evaluation is important to the development of every learner. Data gathering and processing, and decision making, at the student and teacher level, serve as means of identifying strengths and weaknesses.

These specially designed learning packages contain many kinds of informal and formal evaluation.

Observation

In the classroom the teacher has the opportunity to see each student perform every day and to become aware of the level and nature of each student's performance.

Observations are more useful if they are recorded in an organized system. The following list of questions is a sample of types of observations and how they can be collected.

Observation Checklist

1. Does the student approach the work in a positive manner?
2. Is the student struggling with the reading level?
3. Does the student make good use of time?
4. Does the student apply an appropriate study method?
5. Can the student use references effectively, etc.?

	B. Adams	L. Despins	V. Klaissian	H. Smith	K. Dalley
1.					
2.					
3.					
4.					
5.					

Observation may suggest a need for an individual interview with a student.

Individual Conferences

Individual conferences may be paced (scheduled) by the calendar, at certain points in the module, or they may be set up only as needed or requested.

During these conferences teachers can determine the student's progress and can assess the student's attitudes toward the subject, the program, school, and self, as well as the student's relationship with other students. With guided questions the teacher can encourage oral self-assessment; the student can discuss personal strengths or weaknesses in regard to the particular section, module, or subject area.

Self-Appraisal

Self-appraisal helps students recognize their own strengths and weaknesses. Through activities that require self-assessment, students also gain immediate feedback and clarification at early stages in the learning process. Teachers need to promote a responsible attitude toward these self-assessment activities. Becoming effective self-assessors is a crucial part of becoming autonomous learners. By instructing, motivating, providing positive reinforcement, and systematically supervising, the learning facilitator will help students develop a positive attitude toward their own progress.

For variation, students may be paired and peer-assessing may become part of the system. The teacher may decide to have the student self-assess some of the activities, have a peer assess other activities, and become directly involved in assessing the remainder of the activities.

When the activities have been assessed, the student should be directed to make corrections. This should be made clear to students right from the start. It is important to note the correct association between the question and the response to clarify understanding, aid retention, and be of use for study purposes.

Many of the activities include choices for the student. If the student is having difficulty, more practice may be warranted, and the student may need to be encouraged to do more of the choices.

Each section within a module includes additional types of activities called Extra Help and Enrichment. Students are expected to be involved in the decision as to which pathway best suits their needs. They may decide to do both.

Self-appraisal techniques can also be introduced at the individual conferences. Such questions as the following might be included:

- What steps are you taking to improve your understanding of this topic?
- What method of study do you use most?
- How do you organize your material to remember it?
- What steps do you follow when doing an assignment?
- What could you do to become an even better reader?
- Do you have trouble following directions?
- Did you enjoy this module?

A chart or checklist could be used for recording responses.

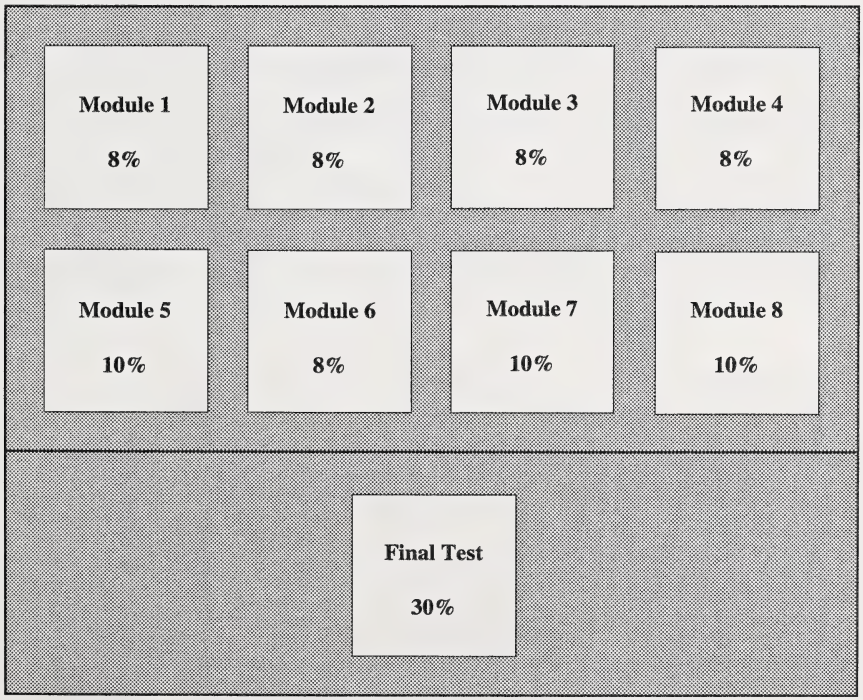
Informal Evaluation: Assignments

Informal evaluation, such as the assignments included in each module, are an invaluable aid to the teacher. They offer ongoing assessment information about the student's achievement and the behaviour and attitudes that affect that achievement.

Each module contains a separate booklet called the Assignment Booklet. This booklet assesses the knowledge or skills that the student has gained from the module. **The student's mark for the module may be based solely on the outcome of learning evident in the assignment booklet; however, you may decide to establish a value for other variables such as attitude or effort.** It is important that you establish at the beginning which outcomes will be evaluated, and that all students clearly understand what is expected.

Final Test

All LFMs include a formal final test which can be photocopied for each member of the class. The test, closely linked to the learning outcomes stated in the module booklets, gives the teacher precise information concerning what each student can or cannot do. Answers, explanations, and marking guides are also included. The value of the final test and each module is the decision of the classroom teacher. Following is a suggestion only.



Introducing Students to the System

Your initiation to these learning materials began with a basic survey of what was included and how the components varied. This same process should be used with the class. After the materials have been explored, a discussion might include the advantages and the disadvantages of learning independently or in small groups. The roles of the students and teacher should be analysed. The necessary progress checks and rules need to be addressed. Your introduction should motivate students and build a responsible attitude toward learning autonomously.

Skill Level

It is important for students to understand that there are certain skills that they will need in order to deal successfully with the course materials. They are listed below:

- understanding and using instructional materials (table of contents, index, list of illustrations, WHMIS labels associated with lab materials, appendices, bibliography, and glossary)
- interpreting lab data, maps, graphs, and charts
- using reference materials
- recognizing special symbols
- using a scientific calculator
- using laboratory apparatus and science skills

Other general skills are using reliable study methods, outlining, and learning to read at a flexible rate.

To decide the level and amount of instruction needed to accommodate the varied levels among students, you may wish to prepare and administer skill inventories or pretests. If most students need help with a particular skill, you may want to plan a total class instructional session. If only certain students lack a skill, you may want to set up a temporary skill group to help students who need it, or you may want to develop a skills file for this purpose.

Reading Level

These course materials are largely print based, but poorer readers need not be discouraged. It is important that you assure the students that these materials have been designed for easy reading. The authors have employed special strategies that lower and control the reading level. Some of them are

- the conscious selection of vocabulary and careful structuring of sentences to keep the materials at an independent reading level
- the integration of activities, examples, and illustrations to break text into appropriate-sized chunks
- the inclusion of many kinds of organizers (advance, graphic, intermediate, concept mapping, post organizers) to help give students a structure for incorporating new concepts

- the recognition that vocabulary and concepts are basic to understanding content materials and, thus, must be handled systematically (defined in context, marginal notes, footnotes, and often in a specialized glossary)

- the acknowledgement that background knowledge and experience play a vital role in comprehension

- the systematic inclusion of illustrations and videos to help poorer readers and visual learners, and audiocassettes and software as an alternative to print-based learning

- a variety of formats (paragraphs, lists, charts, etc.) to help poorer readers who do not absorb or retain main ideas easily in paragraph format

- the inclusion of media and activity choices to encourage an active rather than passive approach

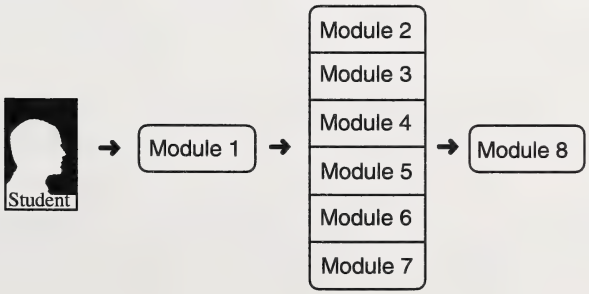
- instruction in a meaningful setting rather than in a contrived, workbook style

- using purposeful reading, viewing, and doing to produce better interpretation of the course materials

- the recognition that students need structured experiences when reading, viewing, or listening to instructional materials: developing pupil readiness, determining the purpose, providing guided instruction and feedback, rereading if necessary, and extending (This structure closely resembles the reading process.)

To help make the learning package more readable, you can begin your module preparation by reading (viewing, listening to) all the related materials that are going to be used. You need a solid background in order to assess and develop a background knowledge for students. The students' experiential bases may be assessed through brainstorming sessions concerning the topic, or by using visuals and guided questions to predict what the topic might be about.

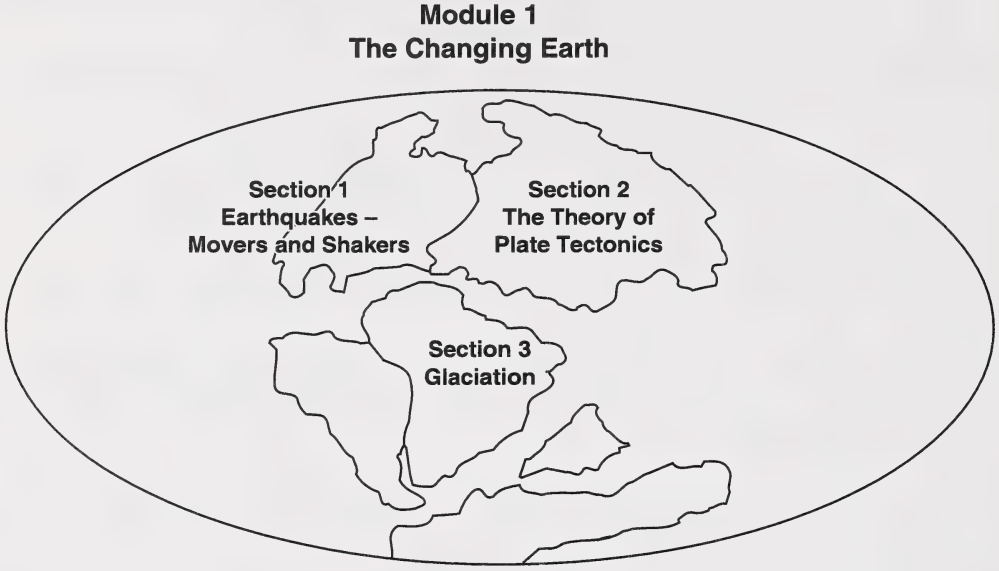
It is recommended that you start with Module 1 because this module includes basic introductory information, and it is also recommended that you end with Module 8 because this module acts as a summary or culmination.



Module 1: The Changing Earth

Overview

The major theme of this module is change. In particular, Module 1 examines changes to the Earth's surface. Both sudden changes (such as those brought on by earthquakes) and gradual changes (such as those brought about by cyclic changes in climate) are examined. Some of the theories that have been developed to explain these changes are also considered and evaluated.



Evaluation

The evaluation of this module is based on three assignments.

Section 1 Assignment	**35 marks**
Section 2 Assignment	**32 marks**
Section 3 Assignment	**33 marks**
TOTAL	**100 marks**

Science Skills Assessment

This module contains a methodology for the assessment of science skills. Assessment is performed by both the student and the teacher. An explanation of skill assessment is given in the introduction of Module 1. Criteria to be used for the assessment of science skills is given in the Appendix of Module 1.

Icons are used to draw the students attention to the areas assessing particular science skills. Not all science skills are assessed in all activities. Science skills are assessed in a variety of activities. These include laboratory investigations, library research projects, questions which involve designing charts, and so on. Any activity that fosters the growth of students abilities as problem solvers can be used for science skills assessment. It is recommended that you obtain the most recent information on science skills assessment from the Student Evaluation branch of Alberta Education.

Materials and Equipment

The following is a list of materials and equipment necessary for an individual to complete the investigations and activities in Module 1. Adjust the amount of equipment if more than one individual is involved.

Section 1: Activity 2

Investigation: Investigating Wave Motion

- large-diameter Slinky®
- masking tape
- timing device
- two chairs
- table
- string or elastic bands

Note: The three items in the second column are required by students working alone.

Section 1: Activity 3

Investigation: Interpreting Data from Earthquakes

- pencil
- compass
- ruler
- map of Alberta (provided in Appendix)

Section 1: Activity 4

Investigation: Simulating Surface Motion

- soft foam block
- 2 felt markers
- sheet of transparent acetate
- permanent marker
- scissors
- ruler
- chairs (optional)
- books (optional)
- clothespins (optional)

Section 2: Activity 1

Investigation: Rejoining the Continents

- world map (provided in the Appendix)
- scissors
- tape or glue
- sheet of paper

Section 2: Activity 2

Investigation: Observing Convection Currents in Action

- glass cooking pot
- 1 cup rolled oats
- 2 cups water
- heat source

Section 2: Activity 3

Investigation: Predicting and Locating Geological Activity

- atlas with a physical map of the west coast of Canada and of the world
- Plate 1.4 from page P-2 of *Visions 2*
- Table 1.4 on pages 22 and 23 of *Visions 2*

Additional Resources

Alberta Education. *Science 20 Teacher Resource Manual*. Edmonton: Department of Education, Curriculum Branch, 1993.

Miller, David, Deborah Miller, and Andrius Valadka, *Visions 2 Teacher's Guide*. Toronto: Gage Publishing Company, 1992.

Bishop, Margaret S., and Phyllis G. Lewis. *Focus on Earth Science*. Columbus: Charles E. Merrill Publishing Co. 1972.

Jackson, Joseph H., and Edward D. Evans. *Spaceship Earth, Earth Science*. Toronto: Houghton Gifflin Company. 1980.

Plummer, Charles C., and David McGeary. *Physical Geology*. Dubuque: WM. C. Brown Publishers. 1988.

Jackson, Lionel E., and Michael C. Wilson. *Geology of the Calgary Area*. Calgary: Canadian Society of Petroleum Geologists. 1987.

Smith, D. G. *Landforms of Alberta*. Edmonton: Alberta Remote Sensing Centre; Alberta Environment. 1987.

Osborn, Gerald; *Glaciation – an Alberta Perspective*. Calgary: Media Services Group, Instructional Services Department, Calgary Board of Education.

The following articles from issues of *Earth – The Science of Our Planet*. Waukesha: Kalmbach Publishing Co.

- Dawson, Jim. "CAT Scanning the Earth." (May 1993): 36.
- Yoom, Carol. "The Ice Ages." (May 1993): 20.
- Alper, Joe. "Shaking Seattle." (July 1993): 20.
- Waters, Tom. "Roof of the World." (July 1993): 26.
- Yulsman, Tom. "Charting Earth's Final Frontier." (July 1993): 36.
- Culotta, Elizabeth. "Past Climates hold clues to global warming." (September 1993): 20.

Mandatory Videos

Section 2: Activity 1

The Birth of a Theory, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network, available from Learning Resources Distributing Centre.

Optional Videos

Section 1: Activity 2

Living With Earth: *Part 1*, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network.

Section 1: Activity 5

Earth's Interior, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network.

Section 1: Extra Help

Earthquakes, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network.

Section 2: Enrichment

Plate Dynamics, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network.

Other Videos which may be used with this module are as follows:

- *The Restless Planet*, Earth Revealed series, Magic Lantern Communications Ltd.
- *Glaciers*, Earth Revealed series, Magic Lantern Communications Ltd.
- *The Sea Floor*, Earth Revealed series, Magic Lantern Communications Ltd.
- *Wind of Change*, Planet Under Pressure series, TV Ontario.
- *The Comfort Blanket*, Planet Under Pressure series, TV Ontario.
- *The Climate Puzzle Part 2*, Planet Earth series, WQED Pittsburg.

Section 1: Earthquakes – Movers and Shakers

Key Concepts

- Sudden changes to the Earth's surface (such as earthquakes) cause destruction, injury, and loss of life.
- To save life and property, scientists are working to better understand and predict these changes.
- Scientists have learned much about the Earth and changes that occur on its surface by investigating earthquakes.
- The study of Earth's crustal movement has led to the development of new technologies used to better understand and predict changes to the Earth's surface.
- Scientists can accurately measure the strength of an earthquake, pinpoint its location, and classify certain areas as earthquake zones.
- Scientists cannot predict the exact time and location of future earthquake activity.
- Much data from previous earthquakes is being used to reduce seismic risk for people living in earthquake zones.

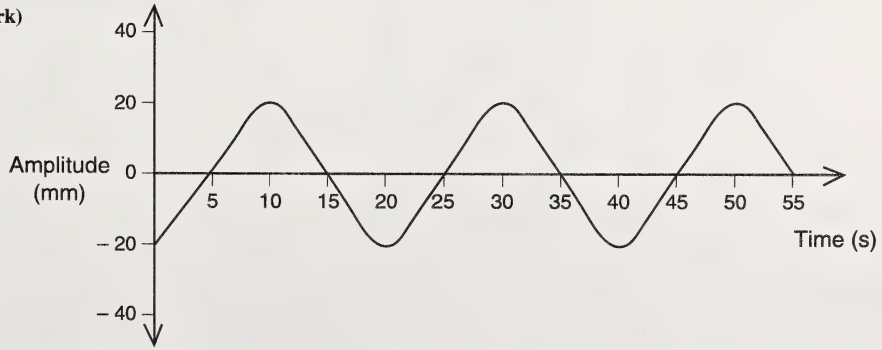
Teaching Suggestions

This section can be introduced with a discussion of the 1989 San Francisco earthquake, the 1993 Los Angeles earthquake, or by watching the video entitled *Living With Earth*: *Part 1*. Starting with the slinky investigation would give students concrete ideas on wave motion.

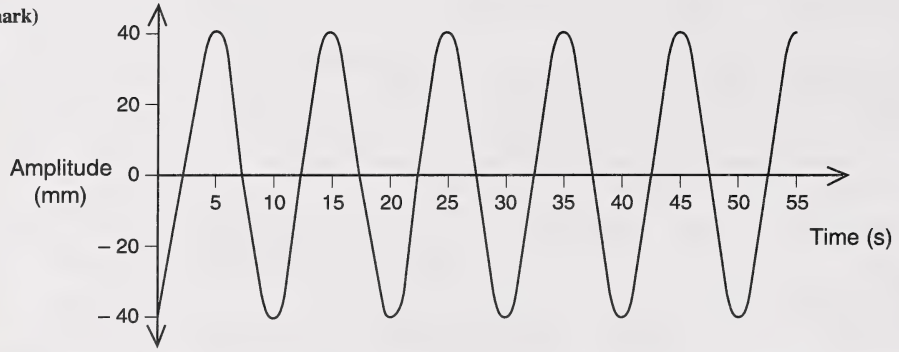
Section 1: Assignment Answer Key (35 marks)

1. P- and S-waves are similar in that they are both seismic waves resulting from an earthquake. P- and S-waves are different in that P-waves are faster and are longitudinal (particles of matter move parallel to the direction of wave motion), while S-waves are transverse (particles of matter move perpendicular to the direction of wave motion). P- and S-waves are also different in that P-waves can move through solids as well as liquids. S-waves can move only through solids. **(4 marks)**

2. a. **(1 mark)**



b. **(1 mark)**



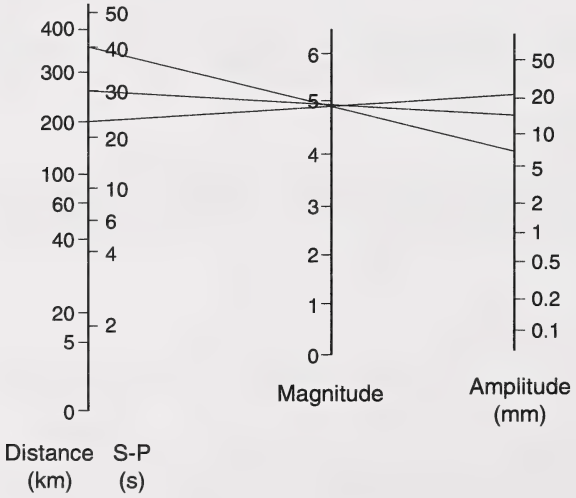
3. The particles in a longitudinal wave move parallel to the direction of the wave. The particles in a transverse wave move perpendicular to the direction of the wave. **(2 marks)**

4. When assigning marks, give one mark for each term used correctly and in a way that helps illustrate its meaning.

   Answers may vary. The following is a example of a possible paragraph.

   Somewhere on Earth an earthquake occurs. Seismic waves resulting from the sudden release of energy travel in all directions. At a seismic station the waves cause a seismometer to vibrate. Attached to the seismometer is a seismograph which produces a record of the earthquake called a seismogram. A seismologist will study this earthquake record as well as those from two other seismic stations. Using the amplitudes of the seismograms and the information based on the other earthquake reading, the seismologist can determine the epicentre and magnitude of the earthquake. **(7 marks)**

5.

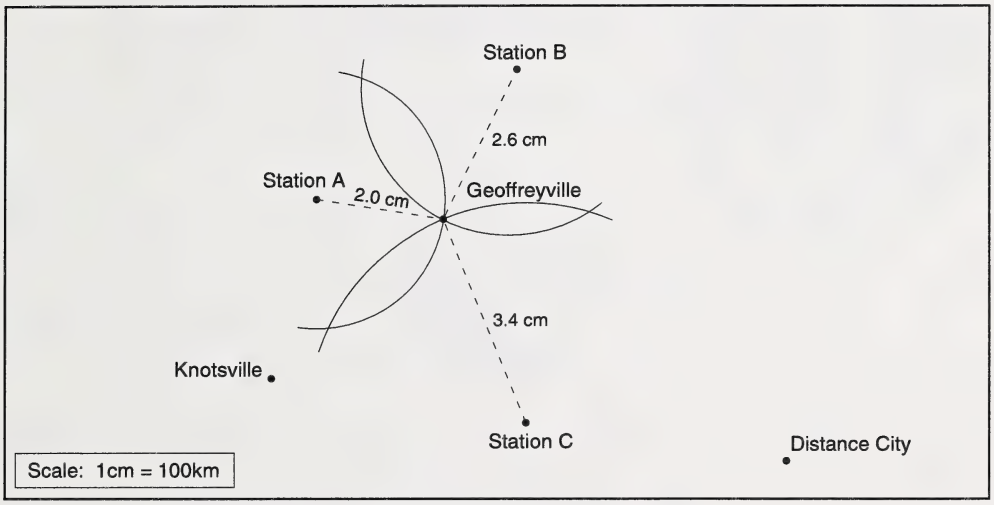


The distances of each station from the earthquake are as follows:

- Station A = 200 km **(1 mark)**
- Station B = 260 km **(1 mark)**
- Station C = 340 km **(1 mark)**

The conversions from kilometres to centimetres are as follows:

- Station A $= 200 \text{ km} \times \frac{1 \text{ cm}}{100 \text{ km}}$
  $= 2.0 \text{ cm}$ **(0.5 mark)**
- Station B $= 260 \text{ km} \times \frac{1 \text{ cm}}{100 \text{ km}}$
  $= 2.6 \text{ cm}$ **(0.5 mark)**
- Station C $= 340 \text{ km} \times \frac{1 \text{ cm}}{100 \text{ km}}$
  $= 3.4 \text{ cm}$ **(0.5 mark)**



(**0.5 mark** for each correctly drawn arc or circle)

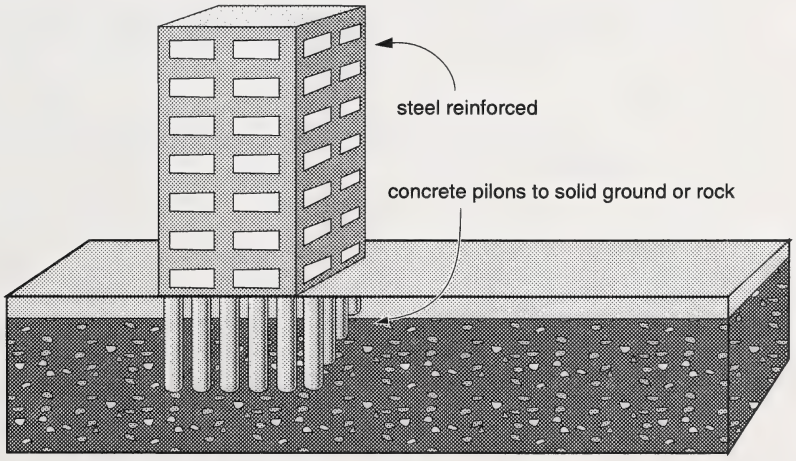
The magnitude of the earthquake was approximately 5, and the epicentre was in Geoffreyville. **(2 marks) (8 marks in total)**

6. The ground motion of an earthquake with a magnitude of 7.1 is about 100 times greater than the earthquake from question 5. **(1 mark)**

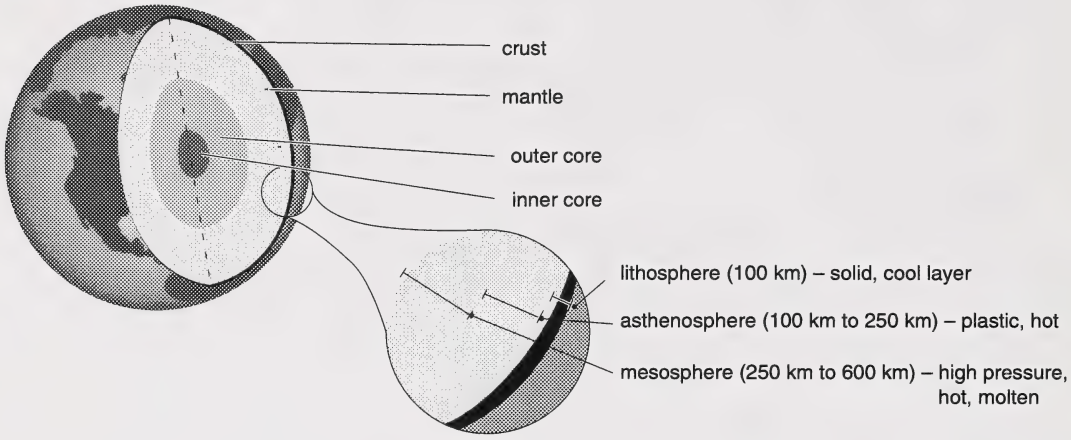
7. Answers will vary. Assign two marks for the sketch and one mark for each plausable method discussed.

Since this is a tall tower, it should be placed on reinforced concrete pilons down to solid ground or rock. The tower itself must be steel reinforced so it is flexible. Natural gas lines are flexible and the floors are reinforced with steel so they can withstand ground movement.

Other methods may also be acceptable for one mark. **(5 marks)**



8. Sketches will vary but should show the following information. Assign three marks for the sketch showing the crust, the mantle, the outer core, and the inner core. Assign another three marks for describing and locating the lithosphere, the asthenosphere, and the mesosphere. **(6 marks)**


crust
mantle
outer core
inner core
lithosphere (100 km) – solid, cool layer
asthenosphere (100 km to 250 km) – plastic, hot
mesosphere (250 km to 600 km) – high pressure, hot, molten

Section 2: The Theory of Plate Tectonics

Key Concepts

- Seismic data and other indirect evidence suggests that the Earth consists of two different thicknesses of crust over a plastic asthenosphere, surrounding a liquid outer core and a solid inner core.
- The theory of plate tectonics suggests that Earth's crust is made up of different-sized plates riding on the plastic asthenosphere.
- Convection currents exist in this plastic layer due to differing temperatures and densities of mantle material.
- Convection currents move crustal plates about.
- Crustal plates collide, pull apart, or slide past each other at their boundaries.
- Changes to the Earth's surface, both sudden (like earthquakes and volcanoes) and gradual (mountain building and the formation of island arcs), can be explained by considering the forces at work along plate boundaries.

Teaching Suggestions

To start this section, students can be asked to write a paragraph on what they think the interior of the Earth is like. This can then lead to a class discussion on the topic.

Section 2 Assignment Answer Key (32 marks)

1. Answers may vary but should cite one of the following for each group.

   a. paleontologists

   - fossils of a *Mesosaurus*
     - These fossils were found in both Brazil and South Africa. This helps support the idea that these areas that are now separated by an ocean could have been joined in the past.

   - fossils of a *Glossopteris*
     - These fossils of the same time period were found all over the southern hemisphere in areas now separated by an ocean.

   (2 marks)

   b. geologists

   - matching rocks
     - Rocks in the Appalachians matched rocks in Canada, Scotland, and Norway.

   - mountain range in South Africa matched one in Argentina
     - These places are now separated by the Atlantic ocean. They must have been joined when the mountain range was forming.

   - plateau in Brazil matches one in west Africa
     - These places are now separated. They may have been joined when this plateau was forming.

   - glacial scratches indicates a glacier moved from Africa to south America
     - This type of glacial movement is only possible if these continents were joined at the time of the glacier.

   (2 marks)

   c. paleomagnetic scientists

   - Scientists discovered a pattern of normal and reverse magnetic stripping to rock along both sides of the oceanic ridges.
     - This indicates that the ocean floor is spreading along the ridges. This supports the idea of moving crustal blocks.

   (2 marks)

   d. geophysicists

   - Scientists determined the rate of ocean floor spreading
     - This showed that the Atlantic opened up at the same time as Wegener's theory suggested it did.

   - Scientists obtained drill core samples.
     - This also showed that the Atlantic ocean opened at the time Wegener's theory suggested.

   (2 marks)

2. Answers may vary but should cite some of the following examples.

   a. sonar

   - the ocean floor has ridges and trenches
     - Ridges are regions of plate divergence where new crustal material is formed.
     - Trenches are subduction zones where crustal material is pulled down into the Earth's interior.

   (2 marks)

b. seismographs

- The interior of the Earth has both solid and fluid zones.
  - The asthenosphere of the Earth's interior is made of a fluid material in which convection currents exist.

(2 marks)

c. magnetometer

- Data showing a striped pattern of normal and reverse magnetism along east and west sides of ocean ridges.
  - Ocean floor is spreading as new material emerges at the ridges.

(2 marks)

3. Observations of the close fit of some continental shelves first led scientists to hypothesize that continents were at one time joined, and are drifting apart. Evidence from many branches of science was then gathered to support the hypothesis. Geological phenomena was then explained using the idea of moving continents. The hypothesis was able to explain much of the observed geological features and phenomena and was therefore accepted as a viable theory. **(4 marks)**

4. The theory of plate tectonics was easier to accept because it involves oceanic and continental plate movement, not just continental plates somehow breaking through solid oceanic plates. The theory of plate tectonics was also able to explain the force responsible for plate movement. **(3 marks)**

5. Convection currents in the semi-solid asthenosphere are believed to be responsible for plate movement. Convection currents occur in any fluid that is heated unevenly. This process is occurring in the atmosphere and in the oceans. **(3 marks)**

6. Oceanic crust is more dense than continental crust; therefore, the oceanic crust tends to sink under the lighter, more bouyant continental crust. **(2 marks)**

7. At plate boundary A, the plates are moving apart. This may result in the formation of a ridge where magma rises to the surface and pushes the plates apart as it cools to form new crustal material. **(2 marks)**

   At plate boundary B, the plates are grinding past each other. This may result in the formation of faults along which earthquakes may occur as stresses build up. The fault zone may also create huge canyons along the ocean floor. **(2 marks)**

   At plate boundary C, a less dense continental plate is converging with a more dense oceanic plate. Great oceanic trenches may result as the oceanic plate dives down into the interior of the Earth. The subduction of the oceanic plate will set off earthquakes and generate heat that melts crustal material and allows magma to rise. The rising magma may form chains of volcanoes. The continental plate will compress as it overrides the oceanic plate, creating mountains as the crust buckles. **(2 marks)**

Section 3: Glaciation

Key Concepts

- Evidence indicates that huge glaciers have covered most of Canada several times in the last two million years.
- Repeated glaciation has shaped the topography and formed the drainage pattern of Canada.
- Current theories suggest that the geometry of the Earth's orbit around the sun could explain periods of glaciation.
- Ice core samples give evidence that Earth's climate has gone through cyclic changes and that the composition of Earth's atmosphere has changed throughout its geological history.
- Changes in the composition of the atmosphere can cause changes in Earth's climate.
- At present, scientists do not agree on predictions of global warming.
- Certain measures can be taken to reduce the emissions of greenhouse gases that may lead to global warming.

Teaching Suggestions

This section could be introduced by having students who have visited the Columbia Icefields describe their experience and what they saw.

Section 3 Assignment Answer Key (33 marks)

1. It is suggested that two marks be given for each glacial feature and explanation of how it was formed.

   A – serrated linear crest

   - A sharp ridge of material deposited between two glaciers or two parts of a single glacier.

   B – cirque

   - These horseshoe-shaped basins are formed by ice plucking and undercutting high peaks and ridges.

   C – lateral moraine

   - These ridgelike piles of rock form along the sides of a glacier. Most loose material that falls from the steep cliffs along the course of a glacier accumulates along the edges of the ice. This material is then deposited along the edge as the ice melts.

   D – medial moraine

   - This ridge of rock material is formed where tributary glaciers came together and join their adjacent lateral moraines.

   E – end moraine

   - A ridge of rock material formed at the end of the glacier where ice is melting. The flowing glacier will continue to bring debris to this end point.

   F – glacier snout or toe

   - The leading or retreating edge of the glacier.

   G – outwash plain

   - A terrace formed adjacent to or in front of the glacier. The terrace is formed by the deposition of fine debris carried along by meltwater.

   H – U-shaped valley

   - Glaciated mountain valleys are erroded into this characteristic U-shape with steep walls and a flat floor as ice flows down them, scraping and rounding off irregularities.

   (8 marks)

2. The glacial feature in the photograph is hummocky moraine. Hummocky moraine is believed to have formed when debris carried by a glacier accumulated in pockets where the ice melted faster than the rest of the glacier. **(2 marks)**

3. Evidence for repeated periods of glaciation has come from the following sources:

   - landscape features – For example, scientists have found glacial deposits from newer glaciers lying on rock surfaces that were scratched and polished by previous glaciers.

   - $^{16}_{8}O$ to $^{18}_{8}O$ ratios in fossil shells indicates that the climate has gone through repeated periods of warming and cooling.

   - Fossil evidence indicating that sea levels have dropped and raised corresponding to temperature changes.

   (3 marks)

4. Three factors currently believed to be responsible for cycles of glaciation are as follows:

   - Earth's orbit around the sun is more elliptical at some times than at other times. This brings the Earth closer to the sun at times and farther away from the sun at other times.
   - The Earth's tilt varies. When the Earth is tilted at the minimum angle (22°) it receives the least direct sunlight.
   - The wobble in the Earth's axis of rotation affects the amount of solar radiation received by an area.

   (3 marks)

5. Two human activities contributing to the buildup of greenhouse gases in the atmosphere are the burning of fossil fuels and deforestation. **(2 marks)**

6. CO_2 emissions could be cut by switching from oil to gas whenever possible. Other possible ways are to increase use of clean energy sources such as hydroelectric, solar, and wind energy. **(2 marks)**

7. Answers may vary. Some possible questions are as follows:

   - Is the increase in CO_2 directly related to society's actions, or is there another possible reason?
   - Is the average global temperature actually increasing?
   - How would an increase in temperature affect the planet?

   (3 marks)

8.

Dangers of Action Without Being Certain	Dangers of Delaying Action
• may spend much money trying to correct a situation that does not need correcting • the action taken may do more harm than the problem	• may cost more to fix the situation later • may not be able to fix the situation if you wait too long

   (4 marks)

9. a. Answers may vary. The following are some examples of possible answers.

      - Alberta relies heavily on fossil fuels for energy.
      - There are many ranches in Alberta which increase CH_4 (methane) levels.
      - There is a very high per capita of ownership and use of automobiles.
      - There are a number of generating stations that are coal-powered.

      (2 marks)

   b. Answer may vary. The following are some examples of possible answers.

      - Much of Alberta's economy is tied to the oil industry.
      - Many people are employed in the oil industry.
      - Houses, industry, and transportation all rely on fossil fuels for energy.
      - People don't like to spend money on alternate energy research when fossil fuels are cheap and plentiful.
      - Conserving energy will mean a change in lifestyle.

      (4 marks)

Module 2: Life from the Past

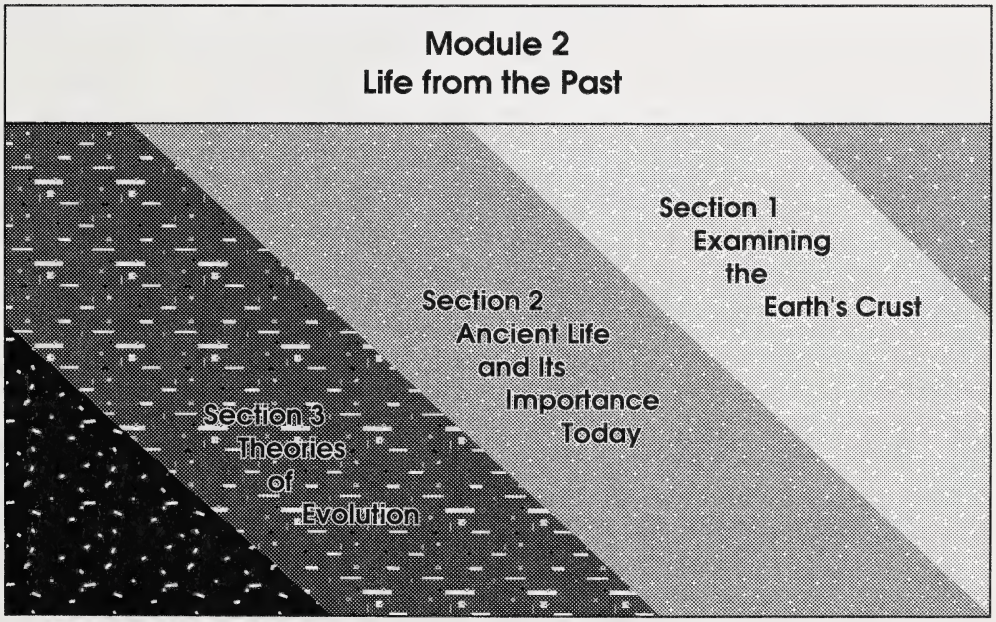
Overview

In this module students examine the changes that have occurred to the Earth's surface and its life-forms over the 4.5 billion years of its existence. The major concepts include the forces within Earth and the interrelated cycles that cause continuous change on the Earth's surface. The students examine the relationships between rock strata and fossils as they provide evidence for the theories involved in paleontology and evolution. Students develop the ability to analyse, connect, synthesize, and integrate data. They will also evaluate the processes of investigating the ancient biosphere, the validity of theories of evolution, and compare them as models of the scientific process.

The first section examines the traits and formation of igneous, metamorphic, and sedimentary rocks and their relationships within the rock cycle. The deposition of sedimentary rock and stratigraphic sequence is covered. Fossil correlation, the geologic time scale, and relative and absolute dating are then examined. In the second section the student investigates paleontology, the geologic column in Alberta, the work of The Royal Tyrrell Museum of Palaeontology, and the formation and recovery of Alberta's fossil fuel deposits. In the third section the student meets Darwin's theory of evolution and the punctuated equilibrium theory of evolution, and examines both in terms of illustrating the scientific method in action.

The STS connections in this module relate to the ways in which science advances technology and technology advances science. The limitations of scientific knowledge and technology are shown. The responsibility of society to protect the environment is covered in terms of the effects of carbon dioxide and ozone in the atmosphere. The relationships of paleontology, stratigraphy, and other aspects of geology and their relationship to the development of our natural fossil fuel resources are dealt with in detail, as are the advancement of scientific knowledge and the development of tourism that come from the work of paleontologists in world known institutions like The Royal Tyrrell Museum of Palaeontology.

Answers for the activities are provided in the Appendix of the Module Booklet. The Enrichment activities are often independent research projects that should be reviewed by a learning facilitator to confirm accuracy of content and relevance of the learning experience.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**40 marks**
Section 2 Assignment	**35 marks**
Section 3 Assignment	**25 marks**
Total	**100 marks**

Materials and Equipment

Section 1: Activity 1

Investigation: General Rock Identification

- 5 or 6 rock samples
- hammer/chisel
- eye protection
- magnifying glass
- vinegar
- water

Investigation: Identifying Three Rock Samples

- photographs of rock samples from your science kit

Section 1: Activity 2

Investigation: Making Your Own Simulated Fossils

- plaster of Paris
- petroleum jelly (Vaseline)
- disposable pie plate or styrofoam dinner plate
- container for mixing plaster
- materials for making imprints (shells, bones, teeth, nuts, crab claws, small irregular rocks, bolts or screws, and so on)
- hand lens

Section 1: Activity 4

Investigation: A Model of Geologic Time

- *Visions 2*
- material to create a scale of some kind (such as a calendar, computer paper, and so on)
- coloured pencil

Section 1: Activity 5

Investigation: Understanding Half-Life

Part A

- 200 pennies or small markers (like bingo markers) with one side of each marked
- 100 nickels or larger markers with one side of each marked
- 100 playing dice
- 3 large containers to hold the coins or markers (1 L jars or cans)
- paper bag
- paper and pencil
- graph paper

Part B

- 100 pennies or small markers (like bingo markers) with one side of each marked
- 100 nickels or larger markers with one side of each marked
  Note: Markers would also work if they were the same size, but a different colour than the ones representing pennies.
- 100 playing dice, if available, but not necessary for this part
- 3 containers to hold the coins or markers (1 L jars or cans)
- paper or pencil
- graph paper

Section 2: Activity 2

Investigation: Performing Field Research

Part A

- camera or video camera (optional)
- rock pick or hammer (optional)
- felt marker
- pencil or paper
- safety goggles
- hand lens or magnifying glass (10×, at least)
- sample bags and ties

Part B

- hand lens or magnifying glass (10×, at least)
- pencil and paper
- camera or video camera (optional)

Part C

- hand lens
- paper and pencil
- photographs numbered 4, 5, and 6 from the loan kit
- some of the resources mentioned earlier in this activity

Section 2: Activity 3

Investigation: Behaviour of Oil and Gas

- 2 clear, similar-sized, glass jars with lids (about 1 L)
- 1 glass jar with lid (0.5 L to 1 L) for mixing oil and coloured water
- 1 glass jar (0.5 L to 1 L) to hold coloured water
- 1 cup of clean, fine sand
- 1 cup of glass beads, extremely coarse sand, or very small pebbles
- measuring cup
- 1 cup of liquid salad or cooking oil
- 1 cup of water
- food colouring

Section 3: Activity 2

Investigation: Changes in the Peppered Moth

- data collected in the field about the peppered and dark form moths as shown in the Observation section

Additional Resources

Thompson, Ida. *The Audubon Society Field Guide to North American Fossils*. New York: Alfred A. Knopf Inc., 1981.

Lambert, David. *The Field Guide to Prehistoric Life*. New York: Facts on File, Inc.

Grzimek, Dr. Bernhard, ed. *Grzimek's Encyclopedia of Evolution*. New York: Nostrand Reinhold Company, 1976.

Shimer, Hervey W., Robert R. Shrock. *Index Fossils of North America*. New York: John Wiley & Sons, 1944.

Moore, C. R. (Hg.). *Treatise on Invertebrate Paleontology*. The Geographical Society of America, 1953.

For additional information, contact the following:

- The Royal Tyrrell Museum of Palaeontology
  Box 7500
  Drumheller, Alberta
  T0J 0Y0

- Geologic Survey of Canada
  3303 – 33 Street NW
  Calgary, Alberta
  T2L 2A7

- Institute of Sedimentary and Petroleum Geology
  Energy Mines and Resources
  3303 – 33 Street NW
  Calgary, Alberta
  T2L 2A7

- Provincial Museum of Alberta
  12845 – 102 Avenue
  Edmonton, Alberta
  T5N 0M6

- Dinosaur Provincial Park
  Box 60
  Patricia, Alberta
  T0J 2K0

- Department of Geology
  1 – 26 Earth Science Building
  University of Alberta
  Edmonton, Alberta
  T6G 2E3

Mandatory Videos

Section 1: Activity 3

Sedimentary Rocks, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network, available from Learning Resources Distributing Centre.

Section 1: Activity 4

Geologic Time, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network, available from Learning Resources Distributing Centre.

Optional Videos

Section 1: Enrichment

Minerals: The Materials of Earth, *Earth Revealed* series, Magic Lantern Communications Ltd.

Volcanism, Earth Revealed series, Magic Lantern Communications Ltd., ACCESS Network.

Section 2: Activity 2

Terrible Lizard, Science Alive series, ACCESS Network, 1993.

Section 2: Enrichment

Petroleum: River of Energy, ACCESS Network.

Section 3: Activity 2

Evolution: Darwin, Naturally, ACCESS Network (VC 289502).

Section 3: Activity 3

Natural Selection, Part 2 – Gradualism Versus the Punctuated Equilibrium Theory of Evolution, ACCESS Network (VC 359100).

Section 1: Examining the Earth's Crust

Key Concepts

- identification of igneous, sedimentary, and metamorphic rocks
- rock cycle
- relative ages of rock layers inferred from stratigraphic principles and fossils
- radiometric procedures used to estimate the ages of rocks and fossils
- half-life
- common types of fossilization
- chronology of natural history shown in sedimentary rocks and their fossils

Teaching Suggestions

- Starting with a local field trip to find and identify various types of rocks may be a good way to interest students in rock types.

- The answers to many of the questions in this module will vary. The answers provided to the assignments try to cover most of the possibilities and in many questions are more than what is required for full marks.

Section 1: Assignment Answer Key (40 marks)

1. Igneous rocks are formed by the cooling of magma (molten rock) as it nears or reaches the Earth's surface. The crystals in igneous rocks are random and either very small (if the magma cooled quickly) or large (if the magma cooled slowly). **(1 mark)**

   Sedimentary rocks are those formed by sediments. Some are formed from weathered rock material deposited in layers by water or wind. Others are formed of deposits of organic material or shells, and so on. Other sedimentary rocks are formed by chemical solutions depositing material in other rocks, in cracks, or in other locations. **(1 mark)**

   Metamorphic rocks are formed from igneous, sedimentary, or other metamorphic rocks that are subjected to extreme pressure and/or heat that change the crystal structure of the original rocks. Often they exhibit thin layers of flattened crystals. **(1 mark)**

2. The rock cycle illustrates the cyclic nature of rock formation. Magma is considered the starting point in the rock cycle. As the magma cools, igneous rock is formed. Weathering and erosion can break down igneous rock which is then deposited to form sedimentary rocks. Original igneous rocks may also be subjected to temperature and pressure and changed into metamorphic rocks. All three types of rocks may be subjected to erosion and weathered into pieces which are deposited to form new sedimentary rocks. In turn, all three types of rocks may be subjected to heat and pressure to form new metamorphic rocks. Another aspect to the cycle has all three types of rocks being subducted and melted into new magma. **(2 marks)**

3. a. Answers will vary but should have characteristics similar to the following:

Photo 7	Photo 8
• has a number of alternating brown and black layers • appears it would split along these layers • layers appear to have been laid down horizontally • fine grain	• appears smooth • appears to have layers that have flowed • has appearance of having been partly melted or reformed under pressure

   (3 marks)

   b. Photo 7: **sedimentary** Photo 8: **metamorphic (2 marks)**

4. a. Obsidian is glossy black, with a grain so fine that it almost looks like glass. Basalt is a dull black with a rough surface and a small grain that is just barely distinguishable. **(1 mark)**

   b. They vary because of the different rates at which the magma cooled. Obsidian is formed from magma that cools very rapidly, so very little crystal formation occurs. Basalt cools a bit more slowly so small crystals develop. **(2 marks)**

5. Limestones, shales, and sandstones are sedimentary rocks which are usually deposited by water at the edges of lakes, oceans, and rivers. These are also ideal places for the bodies of living things to collect and be covered by the sediments. The sediments prevent the organism from completely decaying. Igneous rocks are formed from magma which would incinerate any organic material with which it would come in contact. Metamorphic rocks are also transformed by heat and pressure into new forms. This process would also destroy any fossils that may have been in the original rock. **(2 marks)**

6. a. imprint **(1 mark)**
   b. actual remains **(1 mark)**
   c. mould **(1 mark)**
   d. cast **(1 mark)**
   e. actual remains **(1 mark)**

7. A sandstone sedimentary rock would indicate the shoreline of an ancient ocean while a shale would indicate the bottom of a deep part of the ocean. The movement of waves and streams also sort sediment according to weight, with larger rocks and pebbles being deposited first, then sand, then silt, and so on. So, the further you go from shore, the smaller the pieces of deposited material will be. The stronger the current, the more spread out and the further from shore the deposited material will reach. **(2 marks)**

8. These characteristics suggest that this strata was deposited in a lake. The thin beds of fine-grained material suggest silts being deposited after rainstorms, spring flooding, and so on. The long-reaching lateral layers suggest the material was light and deposited over wide ranges of the lake bed. The mudcracks also suggest a lakeshore in which water levels varied somewhat to let the shore dry and crack, and then be covered by water and sediment again. **(2 marks)**

9. a. principle of uniformitarianism **(1 mark)**
   b. principle of faunal succession **(1 mark)**
   c. principle of original horizontality **(1 mark)**
   d. principle of cross-cutting relationships **(1 mark)**
   e. principle of superposition **(1 mark)**

10. a. The oldest rocks shown in this column are schists, granites, and gneisses. (The terms igneous and metamorphic are also acceptable as answers.) **(1 mark)**

    b. The granite was formed from the slow cooling of magma, most likely in underground intrusions. The gneiss and schist are formed from igneous rocks through metamorphosis. (The gneiss was formed from granite being changed by heat and pressure. Basalt was probably metamorphosed into schist.) **(1 mark)**

    c. A long period of erosion and weathering must have occurred as the rocks were exposed to the elements. The next layers were then laid down once the land was covered with water. **(1 mark)**

11. The limestone layers contain fossils of coral, seashells, and seaweeds. This suggests the limestones were deposited in relatively shallow ocean waters. Coral, in particular, thrives in water with a depth of 25 m to 30 m. Seaweed only lives in the depth of water that receives sunlight. **(1 mark)**

12. The most recent pure sandstone layer contains fossil tracks of reptiles and amphibians in sand dunes, suggesting either desert conditions or the shore of an ocean or lake. **(1 mark)**

13. The most recent sandy shale layer consists of red flood-plain material with land animal and plant fossils. The red colour suggests oxidized iron compounds in the deposits. Sandy shale is usually created when depositis alternate between sand and silt or clay, suggesting changes in the water levels in the plain. The presence of the land plant and animal fossils suggests that the land was reasonably solid and was most likely a rich habitat. **(1 mark)**

14. a. Relative dating shows the relationships among rock strata and the fossils which they contain. Strata can be correlated worldwide by relative dating. This shows the idea of faunal succession very clearly. **(1 mark)**

    b. Absolute dating gives the actual age of the strata or fossil. It gives a more accurate sense of geologic time and a strata's or fossil's place in that time. **(1 mark)**

15. a. Two half-lives have elapsed when 25% of the parent material remains. (At one half-life, 50% of the parent material remains. At the next half-life, half of that remains.) **(1 mark)**

    b. When 12.5% of the parent material remains, it means that three half-lives have elapsed. Three half-lives of $^{14}_{6}C$ is 3×5730 years or 17 190 years. The bone fragment is approximately 17 190 years. **(2 marks)**

Section 2: Ancient Life and Its Importance Today

Key Concepts

- inferring characteristics of life-forms, based on the fossil record
- making inferences about the climate, based on the fossil record
- rock correlations and the geologic column
- main characteristics of environment and life-forms in the four eras of geologic time: Precambrian, Paleozoic, Mesozoic, and Cenozoic
- paleontology and The Royal Tyrrell Museum of Palaeontology
- the geologic column in Alberta
- formation of coal, oil, and natural gas in Alberta
- common types of rock formations that serve as reservoirs for oil and gas
- exploration and recovery of fossil fuels in Alberta

Teaching Suggestions

This section could be introduced with the video *Terrible Lizard* from the *Science Alive* series and a discussion of The Royal Tyrrell Museum of Palaeontology and the badlands.

Section 2: Assignment Answer Key (35 marks)

1. Answers will vary greatly. Hopefully students will see the positive aspects of paleontology as a scientific pursuit, although they are free to argue that it has little value. Look for valid points backed up by concrete details if possible.

   Positive ideas that could be mentioned include the following:

   - value of advancing scientific knowledge
   - tourists visiting The Royal Tyrrell Museum of Palaeontology
   - knowledge of province's history increases pride
   - adds knowledge to help in natural resource development

   Arguments against paleontology having value could include the following:

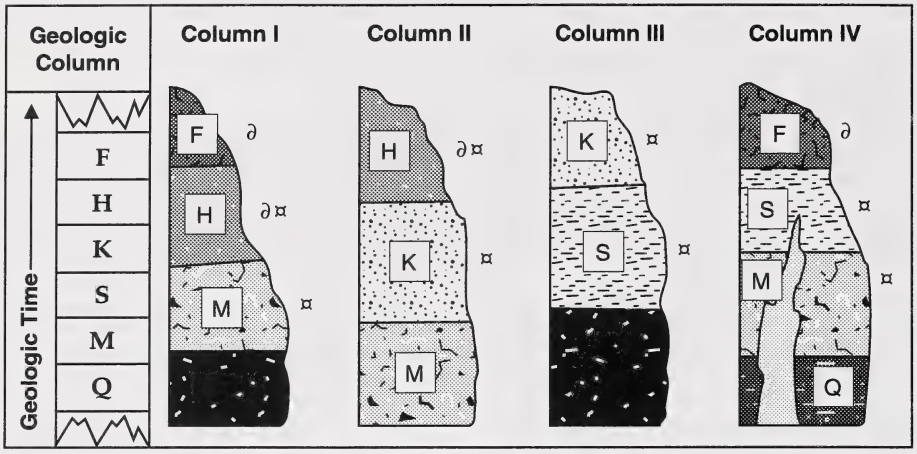
   - Cost doesn't necessarily lead to tangible benefits.
   - Some people don't believe in evolution, paleontological explanations of the geologic column and geologic time, and so on.

   (4 marks)

2. The Earth's atmosphere developed from being inhospitable to life to today's atmosphere that supports life as we know it. As the Earth originally cooled down, there was much convection activity until the crust was finally formed. The volcanism produced such gases as ammonia and methane. Unfiltered sunlight broke up these compounds, releasing nitrogen to build up as the basic gas in the atmosphere and some oxygen. Volcanic action also contributed carbon dioxide, a prerequisite to life. Once plant life could develop, photosynthesis released more oxygen into the atmosphere, and the carbon-oxygen cycles began. The hydrologic cycle also played its role in forming the Earth's bodies of water and producing large amounts of water vapour in the atmosphere. As oxygen accumulated, ozone formation began, which allowed life to move on to land and remain protected from the harmful ultraviolet rays of the sun. Plants and animals then began affecting atmospheric levels of carbon dioxide and oxygen even more. **(4 marks)**

3. The foraminifera fossils would be the most useful as zone fossils as compared to the pelecypod. They appear for a shorter period of time so they will be in fewer strata, thus defining those strata as being laid down in more precise times. The fact that they were widespread around the globe also makes them very useful zone fossils in that these strata in distant places can then be easily correlated with the similar foraminifera-containing strata. **(3 marks)**

4. a. The complete geological column is shown here.



(2 marks)

b. Fossil ¤ stretches across strata layers H, K, S, and M. **(1 mark)**

c. Fossil ∂ stretches across strata layers F and H. **(1 mark)**

5. In the module, numerous instances were shown of paleontology illustrating the scientific process. The history of paleontological principles shows the gradual putting together of a coherent scientific body of knowledge. Basic observable phenomena led to explanations of events that led to the phenomena. A specific example is the development of the idea of uniformitarianism to explain that the development of rock strata in the past must follow the same processes that operate in the present. The module shows the gradual accumulation of knowledge that allowed more defined principles to be stated and led to changes in ideas and theories as new data was found. New techniques were also developed, such as those for absolute dating, to provide more hard scientific evidence to support theories. The constant modification of theories is also shown, especially in the example of the punctuated equilibrium theory of evolution being developed to explain evidence in the fossil record that the gradualist theory of evolution could not address. Other examples could also be cited. **(3 marks)**

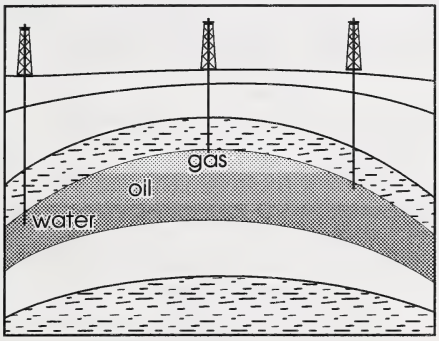
6. The principle of uniformitarianism comes to play here, with the assumption that the organisms in fossil coral required the same environment as today's coral. Since there has been very little change in structure between ancient coral and coral of today, you can assume that the same traits apply. Coral thrives in warm tropical waters with temperatures between 25°C and 29°C; so wherever fossil coral appears, one can assume that the strata was deposited in a warm tropical sea. Coral also survives only at depths between 25 m and 30 m. Thus, as sea levels gradually rose and fell, the coral followed the moving shorelines so it would stay at its optimum depth. These fossils of the moving coral reefs are excellent markers to trace the shorelines of the ancient seas. **(2 marks)**

7. Projects like The Dinosaur Project allow for international sharing of knowledge and expertise. The more ideas and knowledge scientists are exposed to, the more they may come up with new connections that may lead to new explanations and theories. The Dinosaur Project itself allowed Canadian paleontologists to share their expertise with Chinese paleontologists so they can continue to do research in their country. It also allowed Canadian scientists access to the rich fossil areas in China, leading to new discoveries that added to the world's knowledge about group behaviour in dinosaurs and the correlating of fossils and strata to those found in Alberta. Joint scientific projects in other areas could lead to similar types of knowledge expansion. **(2 marks)**

8. The theory of organic fossil fuel formation suggests that remains of sea organisms collected in the seabed and were buried. It is believed that chemical, biological, and maybe radioactive processes, accompanied by heat and pressure, changed the remains into crude oil and natural gas. The fossil fuels then migrated through porous strata and collected in traps under impermeable rock strata. **(2 marks)**

9. The Arctic Embayment was an arm of the sea that stretched into northern Alberta. The rivers that flowed north eroded into the coral reef oil deposits and washed the oil downstream to collect in the sands at the edge of the embayment. It is also suggested that when the sea level increased, marine organisms collected in the shallow mud over the sand and also added their organic material to the sands. **(2 marks)**

10. The same reservoir might contain layers of natural gas, oil, and water, and where the well is drilled into the reservoir will determine what material is reached. The layers stretch through the reservoir to different horizontal distances depending on the thickness of each layer and the shape of the reservoir. Note the following illustration showing the location of three wells each hitting a different material in the same reservoir. **(2 marks)**



11. The three materials layer themselves in reservoirs because they have different specific gravities; thus, as they migrate through the strata the lighter natural gas collects at the top, the heavier crude oil collects below it, and the water, the heaviest material, collects below the crude. **(2 marks)**

12. Alberta's many coal reserves fuel major electrical generating plants, such as those at Sheerness in east-central Alberta and at Wabamun west of Edmonton. Higher grade coal from mines like those at Grande Cache is exported for industrial purposes to countries such as Japan. **(2 marks)**

13. Alberta's geological history has provided Alberta with numerous economic benefits. The massive uplifts and folding that created the Rocky Mountains has created a beautiful landscape that draws tourists from around the world. The Red Deer River valley at Drumheller and Dinosaur Provincial Park near Patricia are also big magnets for tourists interested in badlands landscapes and the rich fossil history, especially of dinosaurs, in those areas. Of course, Alberta's prehistory also left our province rich, fossil fuel resources of natural gas, crude oil, heavy oil, tar sands, and coal. Other economic benefits from our geological history, such as rich farmland, were not referred to in this module.

    Tourism will continue into the future and is predicted to continue to be a growth industry. Coal deposits are immense and will provide production for many years at current production levels. Coal may become even more valuable when other fossil fuel reserves are depleted. Natural gas and conventional crude will continue to be produced for many years, but will gradually be depleted unless major new discoveries are made. Heavy crude and tar sands have huge reserves that can be tapped for many years. New recovery methods and finding new reserves to develop may also help in our future economic health. **(3 marks)**

Section 3: Theories of Evolution

Key Concepts

- evolution of Earth's atmosphere
- development of Darwin's theory of evolution
- natural selection, survival of the fittest, and speciation
- evolution as gradual and persistent modification over long time periods
- punctuated equilibrium theory of evolution
- evolution as an example of the scientific method

Teaching Suggestions

This section could be introduced with a discussion of evolution theory and creationist theory. Note that this may be a sensitive topic and must be handled with an appreciation of the views of others.

Section 3: Assignment Answer Key (25 marks)

1. Lamarck would suggest the whale began as a land animal living by the sea. The animal took to swimming in the sea to search for food and developed parts of its body through the activity of swimming that would make swimming easier. Through the exercise of swimming, an individual's legs might have changed their muscles and bone structure just slightly. The individual might also have developed its ability to control its breath under water. These slight acquired traits were then passed on genetically to the offspring. The offspring also swam for prey and further developed their bodies to help their activities. Over the generations the land animals' legs gradually developed into flippers, the tail developed into flukes, and the breathing system changed to handle extended periods of time under water.

   Darwin would explain the evolution in a different way. Individuals in the population who possessed certain traits that allowed them to swim successfully took to the sea in search of prey. Their existing traits made them very successful, so they survived to make their particular traits more dominant in the gene pool. The traits that made the group successful in the aquatic environment were thus selected out to spread throughout the population. Over many generations traits such as flippers rather than legs, flukes rather than tails, and so on became dominant. **(6 marks)**

2. Natural selection is key to Darwin's theory of evolution. Traits that make a species successful in its environment ensure the survival of the fittest specimens. These successful specimens survive to breed and so their traits are passed on to the next generation of the population. This selecting out of successful traits by the natural processes of surviving in the environment is natural selection. **(3 marks)**

3. a. The south shoreline of the lake will have darker-coloured snakes and the islands will have lighter-coloured specimens. **(2 marks)**

   b. The original snake population had some variation in colour, so the gene pool had information for light and dark colouration. The environment on the south shore, with the dark rocks and heavy grass, would be most suitable for dark-coloured snakes' survival. The darker snakes would be successfully camouflaged against the dark rocks and grass, making them more successful in hunting for prey and avoiding predators. With the survivors being the dark specimens, they would make up most of the breeding pool, and so the trait for dark colouration would become predominant in that population, especially after many generations. Similarly, the snakes that moved out to the islands became a separate population affected by a light-coloured environment. The lighter-coloured members of the original population that arrived there would be the most likely to survive in the light-coloured island environment and so the trait for light colouring would be naturally selected in that population over the generations. **(5 marks)**

4. Niles Eldridge and Stephen Jay Gould in 1972 presented the theory of punctuated equilibrium. This theory contends that species often exist, almost completely unchanged, for millions of years and then disappear. They are replaced by new similar, yet changed, forms. The suggestion is that evolutionary change occurs suddenly, following long periods of little change. These sudden changes provide clear punctuation marks in long periods of equilibrium. Supporters of the theory tie periods of rapid evolutionary change to major geologic changes.

   Darwin's theory was one of gradualism – changes in populations occur gradually over the generations throughout geologic time, and the small changes gradually compound so generations down the line may be significantly different from their ancestors. That is the main difference from the punctuated equilibrium theory. The punctuated equilibrium theory of evolution is still based on many of Darwin's ideas that made up his theory, such as the survival of the fittest and natural selection. **(5 marks)**

5. The first step in the evolution of a new species is the isolation of some members of a population. The separated population then has a separate and particular gene pool that includes the variations present in the individuals in that group. The environment of the separated group varies from that of the original population, so that each population begins a separate evolutionary path. The environment will naturally select traits that enable the organisms to best succeed. Take the example of the Lake Erie water snakes. The shore environment is dark, the population of snakes there succeed best if they are dark, and that trait is naturally selected. The environment on the islands affects the separate population there in a different way. The light-coloured rocks lead to the trait of light colouration being naturally selected in that population. Over many generations in the massive length of geologic time, the separate populations may continue to evolve in more and more divergent ways, so much so that they become so different that if the separate populations happened to come in contact again, they could not successfully interbreed. At that point they have become separate species. A new species has evolved from the original species. **(4 marks)**

Module 3: Matter and Energy in The Biosphere

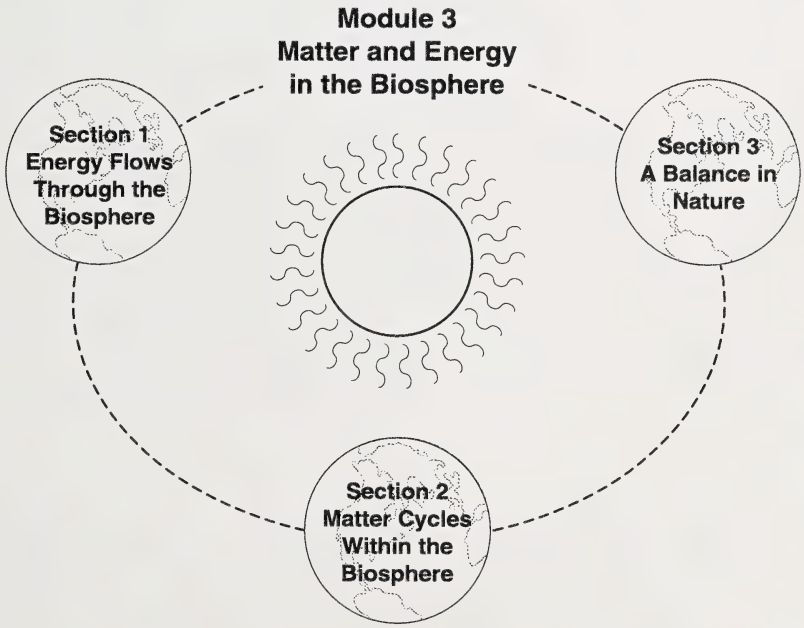
Overview

In this module students examine the flow of energy through the biosphere, the cycling of matter within the biosphere, and the concept that aquatic and terrestrial ecosystems are defined by a range of abiotic and biotic factors. Students develop an ability to use the skills and thinking processes of science, with an emphasis on collecting, recording, organizing, communicating, and analysing data from their investigations.

The first section investigates the relationships among different populations within the biosphere as solar energy flows through them as food energy. The impact of human activities shows the danger of pollution in the food chains of an ecosystem. In the second section the student investigates the water cycle, the carbon-oxygen cycle, and the nitrogen cycle. Again, there is a review of the negative effects of human activities. The essential nature of recycling is presented in graphic detail. The last section attempts to show the student that abiotic factors really determine the quality and quantity of living organisms that produce biomes throughout the biosphere.

The STS connections in this unit illustrate the central role of experimental evidence in the accumulation of knowledge and the ways in which science advances technology and technology advances science.

Answers for the activities are provided in the Appendix of the Module Booklet. The Enrichment activities are often independent research projects that should be reviewed by a learning facilitator to confirm accuracy of content and relevance of the learning experience.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**40 marks**
Section 2 Assignment	**30 marks**
Section 3 Assignment	**30 marks**
Total	**100 marks**

Materials and Equipment

The following is a list of materials necessary to complete the investigation activities in Module 3.

Section 1: Activity 2

Investigation: Energy Intake in a Food Chain

- paper and pencil
- calculator

Section 2: Activity 1

Investigation: Measuring Rates of Precipitation and Evaporation

- four flat-bottomed containers such as ice cream pails, tin cans, glasses, and so on
- ruler

Investigation: Water Loss in Plants

- test tube
- paper
- masking tape or adhesive tape
- cup or glass
- scissors
- 10 mL graduated cylinder
- metric ruler
- plant with leaves (e.g., tomato)
- sharp knife
- fan (optional)
- water
- cotton ball or tissue

Section 2: Activity 3

Investigation: Performing a Risk-Benefit Analysis

- pencil
- paper
- Visions 2

Section 3: Activity 1

Investigation: Investigating Abiotic Factors of Aquatic or Terrestrial Ecosystems

Pathway A

Part A: Aquatic Ecosystem

- suitable stream, river, pond, lake, or slough
- suitable attire and equipment
- dissolved oxygen test kit
- stopwatch
- solar radiation meter
- moisture meter
- metre stick
- wind speed indicator
- pH paper
- note pad
- pen or pencil
- alcohol thermometer
- measuring tape
- stakes
- jars with lids
- rubber dinghy

Part B: Terrestrial Ecosystem

- suitable treed area, vacant lot, or unused area of the schoolyard
- suitable attire and equipment
- stopwatch
- solar radiation meter
- moisture meter
- measuring tape
- wind speed indicator
- alcohol thermometer
- stakes
- compass
- notepad
- pen or pencil

Pathway B

Part A: An Aquatic Ecosystem

- suitable stream, river, pond, lake, or slough
- suitable attire and equipment (i.e., rubber boots)
- note pad
- capped plastic bottle with 5 m of string attached
- stopwatch or watch with a second hand
- pen or pencil
- measuring tape
- thermometer
- pH paper and chart
- jar with lid

Part B: A Terrestrial Ecosystem

- any grassy or treed area (i.e., remote part of the schoolyard, vacant lot)
- suitable attire
- note pad
- pen or pencil
- measuring tape
- thermometer
- stakes

Section 3: Activity 2

Investigation: Drawing and Using Climatograms

- pencil
- paper
- climatogram data

Additional Resources

Corson, Walter H., ed. *The Global Ecology Handbook.*
Boston: The Global Tomorrow Coalition, 1990.

Johnson, Lorraine. *Green Future: How to Make a World of Difference.*
Markham, Ontario: Penguin Books Canada Ltd., 1990.

Minister of Supply and Services Canada. *The State of Canada's Environment.*
Ottawa: Canada Communication Group, 1991.

Monger, Grace, ed. *Revised Nuffield Advanced Science Biology.*
Harlow, England: Longman Group Limited, 1986.

Mandatory Videos

Section 1: Activity 1

Aspects of Ecology: Ecosystems, ACCESS Network, available from Learning Resources Distributing Centre.

Section 2: Activity 3

Recycling: The Endless Cycle, National Geographic, available from Learning Resources Distributing Centre.

Global Warming: Hot Times Ahead, ACCESS Network, available from Learning Resources Distributing Centre.

Section 3: Activity 3

If You Build It, Ducks Unlimited, available through the Friends of Environmental Education Society of Alberta (FEESA), or from ACCESS Network, or from Learning Resources Distributing Centre.

Optional Videos

Section 2: Activity 1

Water: A Precious Resource, National Geographic.

Section 2: Activity 2

Fate of the Earth, Part 1: Geochemical Cycles, *Planet Earth* series.

Section 1: Energy Flows Through the Biosphere

Key concepts

- organization of the biosphere
- quantitative assessment of energy flow through a number of trophic levels
- interactions between organisms in a simple food chain
- describing trophic levels in terms of pyramids of numbers, biomass, and energy

Section 1: Assignment Answer Key (40 marks)

1. Ecologists organize living things according to structure and function. Individuals in a species group together to form a **population**. Many species living in a certain area form a **community**. This larger group of living organisms together with its surroundings form the basic unit of ecology, the **ecosystem**. Collectively, all living things and the Earth form the **biosphere**. **(4 marks)**

2. The abiotic factors are the non-living components of the ecosystem including the climatic (weather), physiographic (land masses), and edaphic (soil) conditions. The biotic factors include all the communities and their interactions. **(2 marks)**

3. The major requirements for an ecosystem are light energy, producers, decomposers, and raw materials such as carbon dioxide, nitrates, phosphates, and other minerals. **(4 marks)**

4. Solar radiation is the initial form of energy that is trapped by plants in the process of photosynthesis. It is transformed into chemical energy in the bonds of carbohydrates. This energy is released by cellular respiration which allows cells to function. Some of this energy is lost in the form of heat energy which dissipates in the atmosphere. **(3 marks)**

5. a. The energy per unit of biomass of organisms is as follows:

$$\text{Level 1} = \frac{19\,500.0\ \text{kJ}}{1000.0\ \text{kg}} \doteq 19.5\ \text{kJ/kg}\ \textbf{(1 mark)}$$

$$\text{Level 2} = \frac{88.0\ \text{kJ}}{6.0\ \text{kg}} \doteq 14.7\ \text{kJ/kg}\ \textbf{(1 mark)}$$

$$\text{Level 3} = \frac{8.2\ \text{kJ}}{0.6\ \text{kg}} \doteq 13.7\ \text{kJ/kg}\ \textbf{(1 mark)}$$

   b. The energy flow is approximately 9.3%. The reason for this is the utilization of energy by the Level 2 organisms to perform their life functions, as well as the energy that is lost as heat during normal activity. **(3 marks)**

   c. The energy pyramid will always be shaped with the largest amount forming the base. This results from the loss of energy at each level in life processes and as heat. The other pyramids may not look like true pyramids because of size and energy storage capacity. **(3 marks)**

6. a. Energy harvested by producers $= 0.023\% \times 5\,000\,000\ \text{kJ/m}^2\text{/a}$
$= 1150\ \text{kJ/m}^2\text{/a}$ **(1 mark)**

b. Energy lost due to harvesting inefficiency $= 5\,000\,000\ \text{kJ/m}^2\text{/a} - 1150\ \text{kJ/m}^2\text{/a}$
$= 4\,998\,850\ \text{kJ/m}^2\text{/a}$ **(1 mark)**

c. Energy used by producers to live $= 40\% \times 1150\ \text{kJ/m}^2\text{/a}$
$= 460\ \text{kJ/m}^2\text{/a}$ **(1 mark)**

d. Energy available to primary consumers $= 1150\ \text{kJ/m}^2\text{/a} - 460\ \text{kJ/m}^2\text{/a}$
$= 690\ \text{kJ/m}^2\text{/a}$ **(1 mark)**

e. Energy harvested by primary consumers $= 20\% \times 690\ \text{kJ/m}^2\text{/a}$
$= 138\ \text{kJ/m}^2\text{/a}$

Energy used to live $= 90\% \times 138\ \text{kJ/m}^2\text{/a}$
$= 124.2\ \text{kJ/m}^2\text{/a}$

Energy available to secondary consumers $= 138\ \text{kJ/m}^2\text{/a} - 124.2\ \text{kJ/m}^2\text{/a}$
$= 13.8\ \text{kJ/m}^2\text{/a}$ **(3 marks)**

f. The percentage of energy stored in producers which is available to the secondary consumers is $\frac{13.8\ \text{kJ/m}^2\text{/a}}{690\ \text{kJ/m}^2\text{/a}} \times 100 = 2\%$. **(1 mark)**

7. Mercury is a heavy metal toxin that finds its way into the food chain of aquatic ecosystems through the mismanagement of industrial wastes. The heavy metals are not excreted by the organisms that take them into their bodies. As a result of feeding patterns, the organisms of each trophic level will accumulate the toxin in their fatty tissues. This process is called biological magnification. Since humans are at the top of the trophic pyramid, the greatest biological magnification will take effect at this level. Therefore, the effect of the toxin will be more devastating for humans. **(5 marks)**

8. One cause for eutrophication is the deposition of sewage into bodies of water. Sewage consists of feces and nitrogenous wastes of animals. A second cause is pollution from the large amounts of fertilizers that find their way into the water. A third cause is thermal pollution that kills the animals and adds organic matter to the water. The enriched nutrient content leads to increased algae and green protists or algal bloom. This uses up the oxygen supplies, especially as aerobic decomposers multiply, use up more oxygen, and die. Thus, the body of water will die and no longer support any larger organisms. **(5 marks)**

Section 2: Matter Cycles Within the Biosphere

Key concepts

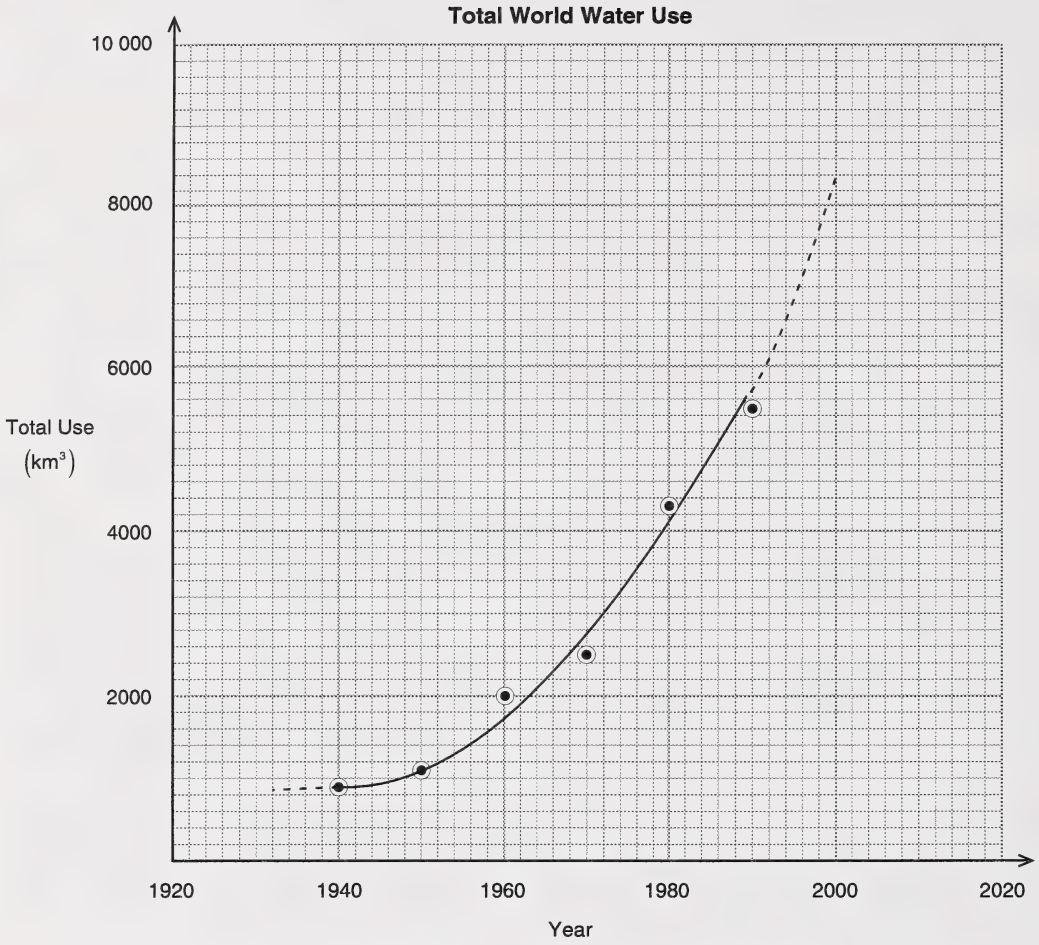
- importance of the hydrologic cycle
- measuring rates of local precipitation and evaporation
- measuring rates of transpiration in plants
- importance of the carbon-oxygen cycle and nitrogen cycle
- how the biochemical cycles are interconnected
- effects of humans on the biogeochemical cycles

Teaching Suggestions

This section can be introduced by having students do the rate of precipitation and evaporation investigation.

Section 2: Assignment Answer Key (30 marks)

1. a. The graph of the results should look like the following. **(3 marks)**



b. The predicted water use for 1930 is about 900 km^3, and the prediction for 2000 is over 8000 km^3. **(2 marks)**

c. There has been an increased demand because more water is needed by the larger populations, more water is needed for industry, and more is needed for irrigation projects. **(3 marks)**

d. When the water evaporates and enters the atmosphere, it will start the journey back as precipitation and once again enter the aquifers that supply the world with its supply of fresh water. **(2 marks)**

2. Living organisms play a role in the cycling of elements such as carbon, oxygen, and nitrogen. The biogeochemical cycles ensure the availability of elements necessary for life. **(2 marks)**

3. The atmospheric levels of carbon dioxide would likely rise if the phytoplankton disappeared since these micro-organisms photosynthesize and remove CO_2 from the atmosphere. Without them, the animal population would add more CO_2 to the atmosphere than would be taken out by the plants. **(3 marks)**

4. First, the carbon atom would be incorporated into a glucose molecule during photosynthesis. Then, the glucose would be transferred to an animal as the plant is eaten. Next, the glucose would be oxidized in the cells of the animal and converted into carbon dioxide. Finally, the CO_2 would be removed in the lungs and exhaled into the air. **(3 marks)**

5. Decomposition of leaves is more rapid in the moist tropics than in temperate regions because decomposers respire faster and temperatures are higher at the soil surface. In the tropics, root systems are extensive and associated with micro-organisms that efficiently exploit a higher proportion of the soil volume than in temperate regions. Roots metabolize and grow faster in the tropics. Also, there is no cold season in which decomposition stops. **(3 marks)**

6. a. This process converts organic nitrogen into ammonia. **(1 mark)**
   b. This process converts nitrates into atmospheric nitrogen. **(1 mark)**
   c. This process converts ammonium into nitrates. **(1 mark)**
   d. This process converts atmospheric nitrogen into ammonia. **(1 mark)**

7. Global warming is caused by an increase in the amount of carbon dioxide and other gases in the atmosphere. This traps water vapour and makes the air act like the glass in a greenhouse by trapping heat. **(1 mark)**

8. a. The global rate of photosynthesis will increase because there is more heat available. Better conditions will allow plants to grow faster and more photosynthesis to occur. **(2 marks)**

   b. The global rate of respiration will also increase because of the favourable conditions for all life-forms. This creates more carbon dioxide which enhances the problem. **(2 marks)**

Section 3: A Balance in Nature

Key concepts

- abiotic factors
- how abiotic factors affect life in an ecosystem and define regions called biomes
- identifying biomes through their abiotic factors
- human activities that affect the abiotic factors of ecosystems

Teaching Suggestions

To introduce this section, students can be asked to list the factors that affect their lives both at home and in the school. These can be divided into physical factors of the home and school and interactive factors. Concentrate on the physical factors and relate these to the physical factors in an ecosystem.

Section 3: Assignment Answer Key (30 marks)

1. a. The lake is Site 3 because there is such a high evaporation rate, nothing is blocking the sun (high light intensity), and a pH value of 7.0 also suggests water. **(2 marks)**

   b. The abiotic physiographic factors for these sites are the altitude and the latitude. **(2 marks)**

   c. The pH value for the forest is more acidic than the meadow because of the slow decomposition and the production of peat. Water percolates through the peat and becomes acidic, thus leaching the soil of nutrients and slowing decomposition. **(2 marks)**

   d. Site 1 (forest) – A decrease in temperature and an increase in wind velocity would most likely eliminate some of the less hardy plants and animals.

   Site 2 (meadow) – A decrease in temperature would reduce the number of types of grasses growing in the meadow. This in turn could reduce the animal population. Increased winds could further reduce the number of types of grasses and perhaps cause some erosion.

   Site 3 (lake) – A decrease in temperature would result in cooler water which would eliminate some plants and animals. Increased winds would cause more evaporation and decreased lake levels. This would eliminate some plants around the lake's edge and cause a reduction in the animal life in the lake. **(6 marks)**

2. Terrestrial biomes are identified on the basis of their type of soil, climate, and physiography. **(3 marks)**

3. The tropical rain forests support the greatest number of species. The main reason for this is the stable temperatures and constant amount of precipitation. All forms of life can survive equally well in the luxury of sufficient raw materials. **(2 marks)**

4. The tundra is much colder and drier than the boreal forest with greater variation in amount and intensity of sunlight. The tundra has a longer day in the summer and a shorter day in the winter. In addition the tundra has a higher latitude and more permafrost. These variations result in a limited variety and abundance of biotic species in the tundra as compared to the boreal forest. **(4 marks)**

5. If the environment is not maintained, there will be a negative impact on all forms of life, including humans! Also, there are so many positive aspects to human activities that could enhance the productivity of the land in Alberta. As wise decisions are made, the quality of life will improve for all life-forms. **(3 marks)**

6. Student answers will vary in length and depth, but each one should include the following main points.

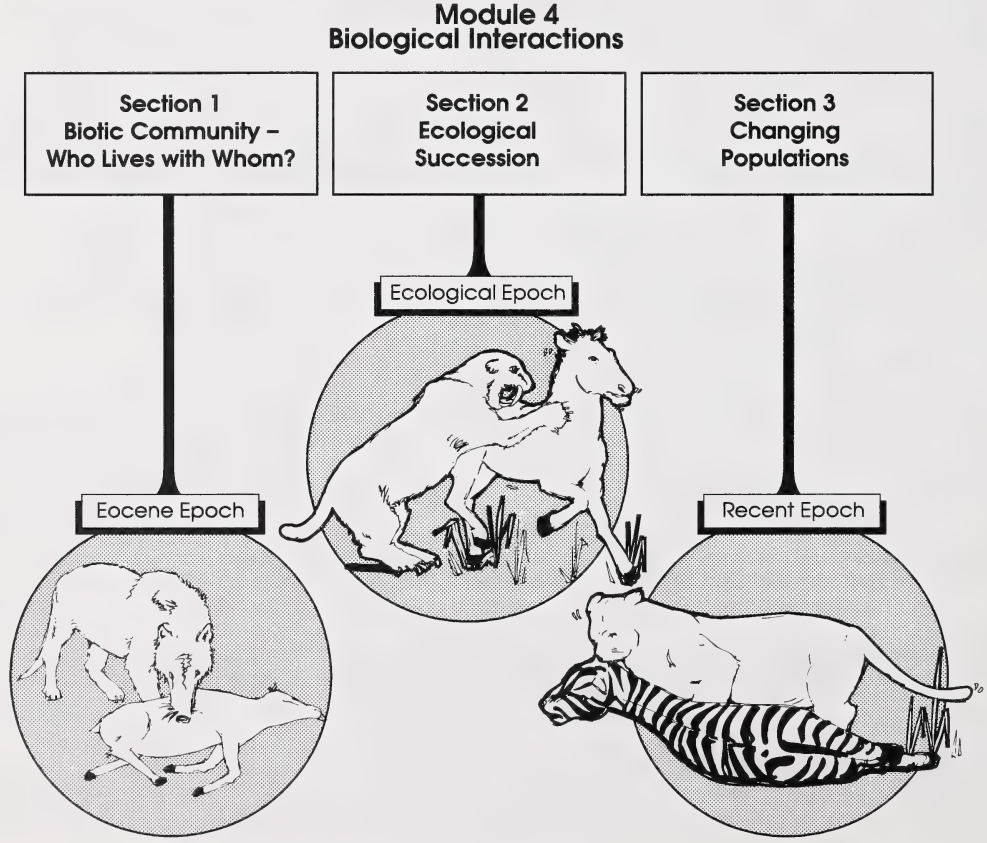
   - Wetlands are the most productive ecosystem. **(2 marks)**
   - Preservation of wetlands is good management. **(2 marks)**
   - Negative impacts will affect humans. **(2 marks)**

   Students should use their own examples as well as examples from the activity.

Module 4: Biological Interactions

Overview

In Module 4 students examine the interaction of organisms, the effect of these organisms on the environment, and how changes to the environment affects their survival. Students will have the opportunity to do a number of investigations, thus extending their science skills. The major theme of change is evident throughout this module.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**33 marks**
Section 2 Assignment	**32 marks**
Section 3 Assignment	**35 marks**
Total	**100 marks**

Classroom Openers

Beginning this module with the soil community investigation would be an excellent way to motivate students. Students will see various species in a biological community first hand. One can then move into the theory of biological communities and the rest of Section 1.

Likewise the hay infusion investigation can be used to open Section 2. This observation of succession can be used to lead into a discussion of ecological succession.

Section 3 could be started with the students making a list of traits of various dogs. This will lead to ideas of variation in a population.

Materials and Equipment

Section 1: Activity 1

Investigation: Soil Community: A Close-up View

Part A

- soil sample
- shovel (spade)
- white enamel pans (or pan lined with white paper)
- magnifying glass
- small glass jars
- tweezers or forceps
- medium-sized glass jar (about 1 L)
- light source
- distilled water
- identification keys (found at the end of the Appendix)
- Berlese funnel
- glass slides (optional)
- light microscope (optional)
- thermometer (if possible)
- pH paper (with a pH scale)
- window screen (20 cm × 20 cm)
- coat hanger wire or other stiff wire

Part B

- sample data

Section 1: Activity 3

Investigation: Predator-Prey Relationships

- an assistant
- 1 envelope
- 4 pegs
- 16 m of string
- a watch with a second hand
- 200 to 300 toothpicks or narrow strips of coloured paper
- food colouring or water colours

Section 1: Enrichment

Investigation: The Fish Tapeworm

- one walleye or northern pike
- filleting knife
- scissors
- hand lens
- stereoscope or microscope (if available)
- tray
- petri dish or small, shallow glass bowl
- alcohol
- forceps (tweezers)
- surgical gloves

Section 2: Activity 1

Investigation: Establishing a Microenvironment and Observing Succession

Part A

- 250 mL beaker, 2000 mL beaker } (or large tin cans)
- plastic wrap
- distilled water
- handful of hay or grass
- eyedropper (or pipette)
- identification keys found in reference books or in the Appendix
- methylene blue stain
- microscope slides
- microscope
- alcohol thermometer

Part B

- data of kinds and number of organisms

Section 3: Activity 1

Investigation: Exploring Factors Affecting Survival

Part A

- copy of Table 6.1
- paper cup
- 1 playing die
- grease pencil
- 4 small disks (plastic or cardboard)

Part B

- copy of Table 6.1
- cup
- 1 playing die
- grease pencil or felt marking pen
- 4 small disks (plastic or cardboard)

Section 3: Activity 3

Investigation: Inferring Significance of Structural Adaptations

- animal encyclopedia that describes the habitats and lifestyles of the mammals in Plate 6.4
- geological time scale (Plate 2.1 and Table E.3 in Appendix E

Section 3: Activity 4

Investigation: Studying Population Growth

Part A

- 2 × 125 mL flasks per group, each containing 49 mL of sterile nutrient broth
- test tubes containing 9 mL of distilled water
- yeast stock (prepared and provided by your teacher)
- sterile 1 mL pipettes and pipette bulbs
- sterile Pasteur pipettes and pipette bulbs
- jars containing bleach (for disposal of used slides and pipettes)
- cover slips
- grease pencil
- microscope
- microscope slides

Part B

- a data sheet of observed yeast growth

Section 3: Activity 5

Investigation: Human Population Growth

- graph sheet
- pencil
- ruler

Section 3: Enrichment

Investigation: Variations Among Individuals

- sample of 10 people
- ruler
- tape measure

Additional Resources

Alberta Education. *Science 20 Teacher Resource Manual.*
Edmonton: Department of Education, Curriculum Branch, 1993.

Newspaper articles

Optional Videos

Section 1: Activity 3

Communities, Ecology series, Magic Lantern, available from Learning Resources Distributing Centre.

Section 2: Extra Help

Succession: Sand Dunes to Forest, Ecology series, Magic Lantern, available from Learning Resources Distributing Centre.

Section 3: Activity 3

Organic Evolution: Darwin, Naturally, ACCESS Network 289502.

Section 3: Extra Help

Aspects of Ecology: Populations, ACCESS Network 241803.

Other videos which may be used with this module are as follows:

Organic Evolution – In the Beginning, ACCESS Network 289501.
Natural Selection, Part 1 – Human Relations Media, ACCESS Network VC359101.
Natural Selection, Part 2 – Human Relations Media, ACCESS Network VC359102.

Section 1: Biotic Community – Who Lives with Whom?

Key Concepts

- A biotic community is made up of all the species living in a geographic area.
- Some organisms live in symbiotic relationships.
- The predator-prey relationship is an important part of many communities.
- Species compete among themselves as well as between species.
- Sometimes organisms enter a new area causing disruption.

Section 1: Assignment Answer Key (33 marks)

1. a. The ecosystem shown in the picture includes all the non-living (abiotic) components such as air, sunlight, clouds, mud, soil, and water as well as the living (biotic) components which include all the organisms shown. The community includes only the living organisms in the picture. **(1 mark)**

   b. The beaver helps to regulate the aspen poplar population, which is labelled H in the picture. The poplar's stems and branches are also used to build the beaver's houses and dams. **(1 mark)**

   c. Answers will vary, but each should include what the organism eats, how it gets its food, where it lives in the community, how it spends most of its time, where it produces its young, and so on. The niche of a mallard duck, for example, would include the following points:

      - The mallard duck spends much of the day swimming around and feeding on the waterweeds and invertebrates such as snails and insects. It will also move out on land to feed on grain.
      - The mallard duck nests on the ground along the shore or in tall grass and shrubs nearby, making its nest from grass and down.
      - It migrates south for the winter.

   (3 marks)

   d. Most of the decomposers would be found in the mud along the bottom of the pond, in the area labelled D in the picture. This is where dead water plants and other organisms settle and accumulate in greatest amounts, providing food for the decomposers. **(2 marks)**

2. a. The increase in food supply leads to a higher survival rate of young and adult moths. This accounts for the rapid population increase. **(1 mark)**

   b. Pesticides kill not only the pest organism but also the predators that normally regulate the pest population as well as many other useful insects in the area. **(1 mark)**

   c. Natural predators of pests should be cultured and released to kill pest organisms as a form of biological control. **(1 mark)**

3. a. mutualism **(1 mark)**
   b. interspecific competition **(1 mark)**
   c. intraspecific competition **(1 mark)**
   d. parasitism **(1 mark)**
   e. predation **(1 mark)**
   f. commensalism **(1 mark)**

4. Although the cow does not normally kill its food organism as the cougar does, both the cow and the cougar feed on other organisms which, according to the definition of predation, makes them predators. **(2 marks)**

5. This is a mutualistic symbiosis. *Escherichia coli* produce vitamin K for humans and make it more difficult for disease-causing organisms to become established in the human intestine. In turn, humans provide the bacteria with nutrients, water, and a place to live. **(3 marks)**

6. Humans alter the composition of natural communities by

   - draining wetlands
   - hunting
   - regular burning
   - mining
   - polluting the environment
   - removing mature trees and damaging saplings through logging
   - replacing wetlands or forests with farmland
   - clear-cutting for pulp mills
   - excessive trespassing with all-terrain vehicles

   (3 marks)

7. Parasites generally do not kill their hosts because in doing so they would destroy their home and their source of food. **(1 mark)**

8. a. Predators helped to control the size of the deer population. **(1 mark)**

   b. The deer population increased gradually at first and then more rapidly. **(1 mark)**

   c. When the deer population reached its peak, there was intense intraspecific competition for food, which was being eaten faster than it could grow back. The high amount of stress during this time reduced reproduction and lowered the deer's resistance to disease. **(2 marks)**

   d. They likely reintroduced the natural predators to stabilize the deer population. **(1 mark)**

9. The following points should be included in the case-study report:

   - the alewife in the Great Lakes

     Like the lamprey, the alewife invaded the Great Lakes from the sea through the Welland Canal some time early in the 1930s. Between 1931 and 1965 this small plankton-eating fish multiplied so rapidly that it came to account for about 90% of all fish in the upper Great Lakes.

     There were no natural predators to keep them under control and they crowded out more desirable species of plankton feeders which served as food for larger, commercially valuable fish. The alewives bred so profusely that they frequently outstripped their own food supply and died off in enormous numbers during the summers. The resulting stench and swarms of insects greatly decreased recreational opportunities, causing economic losses from a rapidly declining tourist industry.

     After considerable research, biologists decided to use biological control in an attempt to reduce the alewife population. Coho salmon were deliberately introduced into the lakes in the late 1960s. The coho is a highly adaptive sports fish that feeds on fish such as the alewife. The results were spectacular. The coho gobbled up alewives and grew at incredible rates with all the available food. In three years the coho salmon were widely distributed in the lakes and the alewife population decreased sharply.

   - the gypsy moth in North America

     The gypsy moth was introduced to North America in 1869 in the hope that its larvae might be used to start a silk trade on this side of the Pacific. The moths quickly multiplied by feeding on the leaves of deciduous trees in the northeastern states, but they caused extensive damage.

     One method of control is the release of the spores of a particular parasitic bacterium into the soil where it attacks the moth pupae. Another involves the use of pheromones to attract and trap males before they are able to mate.

   (3 marks)

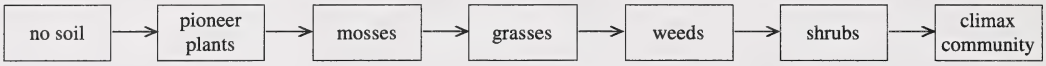
Section 2: Ecological Succession

Key Concepts

- Succession can be observed in a hay infusion.
- Two types of succession can be observed.
- Secondary succession can be observed locally (i.e. abandoned field, cutline, and so on).

Section 2: Assignment Answer Key (32 marks)

1. Succession is the gradual replacement of one community by another during the biological development of an area. One reason for succession is that organisms, especially plants, tend to progressively change environmental conditions over time, making the abiotic factors suitable for new organisms. Plants that come first or early in succession are smaller, hardier, and grow and mature more quickly while those of later communities are larger and take more time to become established. **(3 marks)**

2. a. 

(2 marks)

   b. primary succession **(1 mark)**

3. One major reason why a climax community may not reestablish immediately is that the seeds of climax plant species take longer to spread, germinate, and grow than many of the weeds and grasses. Another reason could be that the abiotic conditions are not suitable for regeneration of the dominant species of the climax community. **(1 mark)**

4 a. The primary cause of succession in the swamp is the accumulation of vegetation which fills sections of the swamp and causes the formation of peat on which terrestrial plants can take root. **(1 mark)**

   b. The abiotic factor is fire. **(1 mark)**

   c. The pioneer plants are the waterweeds which are the first plants to become established and give rise to soil formation (peat). **(1 mark)**

   d. waterweeds, frogs, herons → sedges, grasses, lizards, snakes, gallinules, rails → flowering plants, pitcher plants, Venus flytraps → ferns, shrubs → trees → cyprus trees, large vertebrates
(3 marks)

   e. The cyprus forest is the climax community both before and after the construction of the sill since it is the final community to appear in the natural order of abiotic changes which cause the succession of communities. It finds the solid ground and drier conditions most suitable, and so it replaces the small trees that form the tree islands. **(2 marks)**

   f. The succession is primary because it involves the formation of soil on which a terrestrial community eventually develops where no such community existed before. Each time the climax cyprus forest burns, the soil (peat) goes with it. Thus, the next cycle of succession must begin with soil formation. **(2 marks)**

   g. The swamp will disappear and a cyprus forest will take its place as the climax community for this area. **(1 mark)**

5. a. v
   b. iii
   c. vi
   d. ii
   e. i
   f. iv
(3 marks)

6. The coniferous trees are shade tolerant so they are able to grow under the canopy of deciduous trees such as aspens. As they get larger, they shade out the aspens and drop their needles which make the soil acidic. The conditions created by the spruce are unsuitable for the aspens so they die out. **(2 marks)**

7. Sediment brought in by streams gradually fills in the lake along with the accumulating dead plant and animal remains which settle to the bottom. **(2 marks)**

8. Primary succession occurs where a community has never existed before, and it involves the gradual formation of soil. An example of primary succession is community development on a fresh lava flow. Secondary succession occurs where a community of organisms already exists, but the dominant plants of the climax community are absent. An example of secondary succession is community development on an abandoned farm. **(2 marks)**

9. Biotic factors include the wedging of rocks by roots as they grow into crevices and the production of mild acids by roots which help to dissolve the cement keeping rock particles together. Abiotic factors include the expansion of water as it freezes in rock cracks, running water, and wind. **(2 marks)**

10. Regeneration of the forest by succession would take much longer than by replanting; thus, the logical strategy would be to replant trees to ensure that a supply of pulp would be available in the future. The factors to consider are the cost of replanting, the success rate of tree survival, and the kind of trees to be planted. You need to consider whether your profits allow you to hire replanting crews. Another factor to consider is whether replanting is a legal requirement. Furthermore, you need to decide whether to plant only the species with commercial value or to consider the needs of animal wildlife as well. **(3 marks)**

Section 3: Changing Populations

Key Concepts

- There is variation in species and populations.
- Nature allows for the fittest of a species to survive.
- The fossil records indicate similar ancestors for many species.
- Nature maintains a balance among organisms through disease and predation.
- The human growth rate is not balanced as man has overcome some of nature's checks.

Section 3: Assignment Answer Key (35 marks)

1. a. Mutation of the original gene for hemoglobin and subsequent mutations of the mutated forms would explain all the variations existing today. **(1 mark)**

   b. The S gene gives its possessors an advantage because they would not succumb to malaria while others not possessing the gene likely would die from the disease. Since these S-gene individuals are more likely to survive and reproduce, more of the people in successive generations would be descendants of the S-gene individuals. The frequency of the gene would thus increase in the population because it is being selected for by the environmental conditions. **(2 marks)**

2. The hand and the flipper are homologous structures which have evolved from a common ancestral structure but have been modified through natural selection to perform different functions. This divergence of a structure into variations which perform different functions is called divergent evolution. In the case of the wings, nature has obviously invented them at least twice, once in the invertebrate world and once in the vertebrate world. The ancestral origin of the bee wing is very different from that of the bird wing making the two structures quite different in anatomy although they perform the same function. Such evolution of structures from two different sources to perform the same function is called convergent evolution. **(4 marks)**

3. Once the two populations of turtles reached their respective islands, they became geographically isolated because individuals from each population never met with individuals of the other population to mate. Because mating between the two populations could not occur, the two populations were reproductively isolated, unable to exchange genetic material or share gene variations. Since the conditions on each island were quite different, each population was subjected to different selection pressures which favoured variations suitable for each specific island. Through the process of natural selection, individuals with the suitable traits survived with greater regularity, propagating more of their own kind until the general population had these favourable features. The gradual change in the characteristics of the turtles which originally were of the same species, giving rise to two groups quite different in appearance and unable to interbreed, is a process called speciation. **(4 marks)**

4. a. The selection pressure is the background colouration of the tree trunks and the rocks on which the moths rest during the day. **(1 mark)**

   b. The dark variety is favoured by natural selection. The dark variety blends with the dark colour of the tree trunk, making it more difficult for predatory birds to see. Preying birds are more likely to see the light-coloured variety; thus, more of the dark-coloured form survives each generation to reproduce. This makes the darker one better fit. **(2 marks)**

c. There would be more dark-coloured moths than light-coloured moths. **(1 mark)**

5. a. The rats must have immigrated from other areas of the city. **(1 mark)**

b. The population fluctuates because the environmental conditions do not remain constant. The amount of food varies over time, as does the prevalence of disease and suitable places to live, especially in the city where buildings can be torn down or cleaned up. **(2 marks)**

6. a. Picture B shows a situation in which selection pressure exits. **(1 mark)**
b. Longer necks would become predominant in future generations. **(1 mark)**

7. a. The student's graph should look like the following. **(3 marks)**

b. The carrying capacity is approximately 30 shrews. **(1 mark)**

c. Environmental resistance was the greatest in the tenth year or 1968. Though other factors could be involved, the supply of food was likely the major factor since this is most commonly the reason for population stabilization. **(2 marks)**

d. The regular fluctuations of the population after it reaches a peak indicates that it is an open population. Such fluctuations do not occur in a closed population. **(1 mark)**

8. Biotic potential is the maximum rate at which a population can increase under ideal conditions. It has increased for humans during the past 100 years because the death rate has dropped, particularly for newborns. Since more individuals survive due to better sanitation, disease control, and health care, there is a greater number of individuals who reach reproductive age and produce offspring. **(3 marks)**

9. The World Commission on Environment and Development suggests sustainable development as a means of overcoming environmental deficit. The four basic goals of this approach are as follows:

    - Humans should maintain essential ecological processes and life support systems. They must reduce pollution and their effects on all life-forms and the abiotic elements of the environment.
    - Humans should preserve biological and genetic diversity. They must preserve natural habitats for all species.
    - Humans should ensure the sustainable use of species and ecosystems by replacing and nurturing what is part of the human heritage.
    - Humans should ensure the sustainability of human systems, particularly as relates to their health and social and economic well-being. This means elimination of toxic chemicals that undergo biological magnification and attempts to solve global concerns such as global warming and ozone depletion. **(5 marks)**

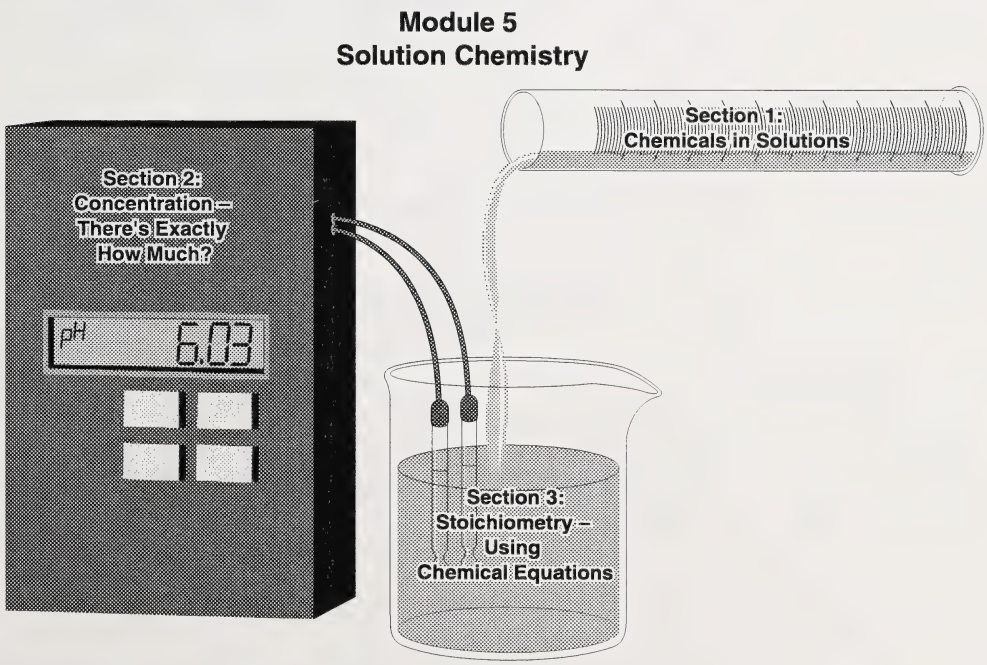
Module 5: Solution Chemistry

Overview

In this module, the solutions are defined in a number of ways. The first section looks at the various classes of solutions such as neutral ionic, neutral molecular, acidic, or basic. It also focuses on the qualitative aspects of these types of solutions.

The second section deals with the quantitative nature of solutions. How they are described by technicians and by scientists. Then after studying concentration, the student practises making solutions in a lab.

The third section is where stoichiometric relationships are explored. This section focusses on how to interpret a balanced chemical equation and how to use it to predict amounts needed or produced in a reaction. The STS connections attempt to connect the science in this module to everyday living. Some of the Enrichment activities are additional labs which should be reviewed by a learning facilitator to confirm the relevancy of the material.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**25 marks**
Section 2 Assignment	**40 marks**
Section 3 Assignment	**35 marks**
Total	**100 marks**

Materials and Equipment

The following is a list of materials necessary to complete the investigations for Module 5. The amounts listed are per student.

Section 1: Activity 2

Investigation: Identifying Ions in Aqueous Solutions

Part A

- 0.10 mol/L standard solutions of:
  - calcium acetate, $Ca(CH_3COO)_{2(aq)}$
  - magnesium acetate, $Mg(CH_3COO)_{2(aq)}$
  - strontium acetate, $Sr(CH_3COO)_{2(aq)}$
- 9 small test tubes
- small beakers
- distilled water
- safety goggles
- 3.0 mol/L test solutions of:
  - ammonium sulphate, $(NH_4)_2SO_{4(aq)}$
  - ammonium hydroxide, $NH_4OH_{(aq)}$
  - ammonium carbonate, $(NH_4)_2CO_{3(aq)}$
- test tube rack
- eye droppers
- test tube clamp
- two unknown solutions of the previously mentioned standard solutions

Part B

Data results are given in the Observations section.

Section 1: Activity 3

Investigation: What Type of Solutes Dissolve to Form Conducting Solutions?

- table sugar
- table salt
- conductivity apparatus
- 2 – 100 mL beakers
- distilled water
- tap water
- test tubes or spot plates (dropper plates)

Investigation: Acids, Bases, and What?

- aqueous salt solution
- vinegar
- distilled water
- test tubes or spot plates
- magnesium metal
- aqueous sugar solution
- baking soda
- red and blue litmus paper
- conductivity apparatus
- steel wool

Investigation: Classifying and Neutralizing Acids and Bases

Pathway A

Part A

- 0.10 mol/L solutions of:
  - vinegar, $CH_3COOH_{(aq)}$
  - rainwater, containing dissolved $SO_{3(aq)}$
  - quicklime, $CaO_{(aq)}$
  - carbonated water, $CO_{2(aq)}$
  - baking soda, $NaHCO_{3(aq)}$
  - lye, $NaOH_{(aq)}$
  - table salt, $NaCl_{(aq)}$
  - sugar, $C_{12}H_{22}O_{11(aq)}$
  - magnesia, $MgO_{(aq)}$
  - ammonia, $NH_{3(aq)}$
- magnesium metal, $Mg_{(s)}$, turnings or strips
- wooden splints
- marking pencil
- matches
- litmus paper
- dropper plates (spot plates)
- eye dropper
- small test tubes
- conductivity apparatus
- plastic wrap

Part B

- 1.0 mol/L $HCl_{(aq)}$
- 1.0 mol/L $NaOH_{(aq)}$
- 10 mL graduated cylinder
- 50 mL Erlenmeyer flask
- phenolphthalein indicator
- universal pH paper, if available
- eye dropper

Pathway B

Part A

- 0.10 mol/L $HCl_{(aq)}$
- 0.10 mol/L $NaOH_{(aq)}$
- household ammonia cleaner, $NH_{3(aq)}$
- vinegar, $CH_3COOH_{(aq)}$
- baking soda, $NaHCO_{3(aq)}$
- laundry soap, contains SO_3^- ions
- sugar, $C_{12}H_{22}O_{11(aq)}$
- table salt, $NaCl_{(aq)}$
- distilled water, $H_2O_{(l)}$
- spot plate
- magnesium metal, $Mg_{(s)}$
- steel wool
- red and blue litmus paper
- eye dropper
- conductivity apparatus

Part B

- 0.10 mol/L $HCl_{(aq)}$
- 0.10 mol/L $NaOH_{(aq)}$
- bromothymol blue indicator
- small test tube
- eye dropper

Investigation: A Home Made Indicator Lab

- purple cabbage
- grater or food processor
- test tubes or bowls
- knife
- pot
- assorted samples

Section 1: Enrichment

Investigation: How Dynamic Can a Solution Be?

- baking soda (or use pickling salt, rock salt, water softening salt, or table salt)
- tap water
- small transparent jar that can be sealed (about 250 mL)

Section 2: Activity 2

Investigation: Preparing and Diluting Solutions

Part A

- copper(II) sulphate pentahydrate, $CuSO_4 \bullet 5H_2O_{(s)}$
- 3.0 mol/L hydrochloric acid solution, $HCl_{(aq)}$
- 0.100 mol/L standard solution of $CuSO_{4(aq)}$
- distilled water
- 10 mL calibrated pipette
- test tubes
- small beakers
- balance
- 25 mL graduated cylinder
- 100 mL volumetric flasks or large graduated cylinders
- plastic squeeze bottles
- pH meter or pH paper
- spatula

Part B

- copper(II) sulphate pentahydrate, $CuSO_4 \bullet 5H_2O_{(s)}$
- balance
- 100 mL volumetric flask or graduated cylinder
- 2 – 100 mL beakers
- distilled water
- 10 mL graduated pipette
- 3 small test tubes
- glass stirring rod

Section 3: Activity 2

Investigation: Preparation of Ammonium Sulphate

- 1.00 mol/L ammonia solution, $NH_{3(aq)}$
- 1.00 mol/L sulphuric acid solution, $H_2SO_{4(aq)}$
- evaporating dish and watch glass
- phenolphthalein indicator
- retort stand
- eye dropper
- Bunsen burner or hot plate
- safety goggles
- 2 – 10 mL graduated cylinders
- stirring rod
- ring clamp
- wire guaze pad
- balance
- striker or matches

Investigation: The Formation of Calcium Carbonate

- $CaCl_{2(s)}$
- $Na_2CO_{3(s)}$
- distilled water
- stirring rod
- 2 – 100 mL beakers
- funnel
- filter paper
- balance

Additional Resources

Summerlin and Ealy, *Chemical Demonstrations*. vol. 1, 2nd ed. Washington, D.C.: American Chemical Society, 1988.

Pesticide Education Program

Mandatory Videos

Section 1: Activity 3

Acids and Bases, World of Chemistry series, Magic Lantern Communications Ltd., ACCESS Network, available from Learning Resources Distributing Centre.

Optional Videos

Section 2: Activity 3

How Safe Is Enough?, Atomic Energy of Canada Ltd., 1983, available from Learning Resources Distributing Centre.

Section 2: Enrichment

S.T.S. Toxilla, ACCESS Network, 1993

Other videos which may be used with this module are as follows:

The Mole Concept, Six Parts, TV Ontario
Toxic Wastes, from the *Perspectives in Science* series, National Film Board.

Section 1: Chemicals in Solution

Key Concepts

- Many common substances are solutions.
- Aqueous solutions can be classified as acidic, basic, neutral ionic, or neutral molecular.
- Ions in aqueous solutions can be identified through qualitative analysis using a solubility table.
- A conductivity apparatus can be used to classify aqueous solutions as electrolytes or non-electrolytes.

Teaching Suggestions

There is some prerequisite knowledge required by students to do this unit. The student must be skilled at writing double replacement reactions and be able to write formulas for ionic compounds. This section emphasizes lab skills. Any demonstrations that supplement the material in the textbook is appropriate. All the laboratory exercises are required to learn the content and processes.

Section 1: Assignment Answer Key (25 marks)

1.

Mixture	Classification
hydrochloric acid	homogeneous
oil and vinegar salad dressing	heterogeneous
a chocolate chip cookie	heterogeneous
ocean water	homogeneous
$Fe(NO_3)_{2(aq)}$	homogeneous
the air	homogeneous

(3 marks)

2. a. A saturated solution of $CaCl_{2(aq)}$ will not dissolve any more solid while an unsaturated solution of $CaCl_{2(aq)}$ can dissolve more solid. Another possible difference is in appearance. The saturated solution of $CaCl_{2(aq)}$ will probably contain some undissolved solute but the unsaturated solution will not. **(1 mark)**

   b. The saturated solution of $CaCl_{2(aq)}$ is believed to be in dynamic equilibrium. **(1 mark)**

   c. The dynamic equilibrium that exists involves two processes: the dissolving of solid $CaCl_2$ into the aqueous form and the aqueous form recrystallizing into solid $CaCl_2$. **(1 mark)**

3. a. $LiOH_{(aq)} + HI_{(aq)} \rightarrow LiI_{(aq)} + H_2O_{(l)}$

   This is a neutralization reaction. **(1 mark for equation; $\frac{1}{2}$ mark for type)**

   b. $KCl_{(aq)} + AgNO_{3(aq)} \rightarrow KNO_{3(aq)} + AgCl_{(s)}$

   This is a precipitation reaction. **(1 mark for equation; $\frac{1}{2}$ mark for type)**

   c. $Na_2S_{(aq)} + CuSO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + CuS_{(s)}$

   This is a precipitation reaction. **(1 mark for equation; $\frac{1}{2}$ mark for type)**

   d. $Pb(CH_3COO)_{2(aq)} + Na_2SO_{4(aq)} \rightarrow PbSO_{4(s)} + 2NaCH_3COO_{(aq)}$

   This is a precipitation reaction. **(1 mark for equation; $\frac{1}{2}$ mark for type)**

4. a. The unknown solution does not contain $Ag^+_{(aq)}$, $Hg_2{}^{2+}_{(aq)}$, $Pb^{2+}_{(aq)}$, or $Cu^+_{(aq)}$, since these ions have low solubility with Cl^- ion and should have precipitated. $(CH_3COO^-$ would precipitate with Ag^+ only.) **(1 mark)**

b. The unknown solution may contain $Ca^{2+}_{(aq)}$, $Sr^{2+}_{(aq)}$, $Ba^{2+}_{(aq)}$, or $Ra^{2+}_{(aq)}$, since any of these ions could have precipitated with the $SO_4^{2-}{}_{(aq)}$ ion and were not eliminated by the first two reactions. **(1 mark)**

c. The ions in the solution can be $Ba^{2+}_{(aq)}$ or $Sr^{2+}_{(aq)}$, since no precipitate was formed with OH^- ion. $Ba^{2+}_{(aq)}$ and $Sr^{2+}_{(aq)}$ have a high solubility with OH^- ion indicating no precipitate would be formed. **(1 mark)**

5. The student report should contain all of the following parts. It need not be exactly the same but should be similar.

Purpose

The purpose of this investigation is to identify three unknown solutions. **(1 mark)**

Materials

- unknown solutions X, Y, and Z
- conductivity tester
- red and blue litmus paper (or bromothymol blue) **(1 mark)**

Procedure

Step 1: Test each solution with a conductivity tester.
Step 2: Test each solution with red litmus paper and blue litmus paper. **(2 marks)**

Observations

Unknown Solution	Conducts Electricity?	Colour of Red Litmus Paper	Colour of Blue Litmus Paper
X	No	Red	Blue
Y	Yes	Red	Red
Z	Yes	Blue	Blue

Note: The student's observations may have the order of the unknowns different from what is given here. **(3 marks)**

Analysis and Interpretation

Note: If the student has a different order of the unknowns in the Observation, then their explanation will be regarding the different unknown. However, the explanations given should be similar.

Unknown X does not conduct electricity and does not change the colour of either red or blue litmus paper. Therefore, it is not an ionic compound, nor an acid or a base; so unknown X must be the sugar solution. **(1 mark)**

Unknown Y conducts electricity and turns blue litmus red while red litmus remains red. This indicates unknown Y must be hydorchloric acid. **(1 mark)**

Unknown Z conducts electricity and turns red litmus blue while blue litmus remains blue. This indicates it is a base. Unknown Z must be the potassium hydroxide. **(1 mark)**

Section 2: Concentration – There's Exactly How Much?

Key Concepts

- Concentration can be defined in a number of ways.
- The primary method of measuring concentration in the laboratory is moles per litre.
- Calculations relating to concentration can be done by two methods: the unit analysis method and the formula method.
- Concentration is very important when it comes to deciding how much of a substance is acceptable in our drinking water.

Teaching Suggestions

Introducing the topic of concentration through issues such as medicines, pesticides, or pollution will add interest and motivate students.

The answers in the Appendix are shown with the significant digits being carried and rounding off of measurements after the last calculation. The intermediate steps are shown as rounded but the display on a calculator to ten digits is actually carried to the final step.

Section 2: Assignment Answer Key (40 marks)

1. a. 0.20 mol/L of $NaOH_{(aq)}$ is more dilute since its concentration is less than 6.0 mol/L of $NaOH_{(aq)}$. **(1 mark)**

   b. 212 ppm of $Al^{3+}{}_{(aq)}$ is more dilute. The units (ppm) show that the solution is dilute. **(1 mark)**

   c. 2.00×10^{-3} mol/L $HCl_{(aq)}$ is more dilute since % by mass is used for solutions that are more concentrated. **(1 mark)**

2. ___F___ process of adding more solvent to change the ratio of solvent to solute

   ___J___ When the amounts are described using measurements and units, then they are being described _____.

   ___H___ unit of concentration that is very low and difficult to measure

   ___L___ the amount of dissolved solute per volume of solvent

   ___C___ piece of equipment used to transfer accurate amounts of liquids

   ___I___ measurement describing the amounts of liquid dissolved in another

   ___A___ A 32 g/100 mL salt solution is more _____ than a 43 g/100 mL salt solution.

   ___H___ a measurement used for measuring amounts of toxins in living organisms

   (4 marks)

3. Students may use either the unit analysis method or the formula method.

   a. **Unit Analysis Method**

   Convert mL to L.

$$2000 \cancel{\text{mL}} \times \frac{1\ \text{L}}{1000 \cancel{\text{mL}}} = 2.000\ \text{L}$$

   Calculate the concentration of barium hydroxide.

$$\text{concentration} = 4.00\ \text{mol} \times \frac{1}{2.000\ \text{L}}$$

$$= 2.00\ \text{mol/L}\ \ (3\ \text{significant digits})$$

   (2 marks)

   Formula Method

   data: $V = 2000\ \text{mL} = 2.000\ \text{L}$ $\quad n = 4.00\ \text{mol}$ $\quad C = ?$

   solution: $C = \frac{n}{V}$

$$= \frac{4.00\ \text{mol}}{2.000\ \text{L}}$$

$$= 2.00\ \text{mol/L}\ \ (3\ \text{significant digits})$$

b. **Unit Analysis Method**

Convert mL to L.

$$45.0\ \cancel{\text{mL}} \times \frac{1\ \text{L}}{1000\ \cancel{\text{mL}}} = 0.0450\ \text{L}$$

Calculate the number of moles of potassium iodide.

$$\frac{0.320\ \text{mol}}{1\ \cancel{\text{L}}} \times 0.0450\ \cancel{\text{L}} = 0.0144\ \text{mol}\ \ (3\ \text{significant digits})$$

(2 marks)

Formula Method

data: $V = 45.0\ \text{mL} = 0.0450\ \text{L}$ $\quad C = 0.320\ \text{mol/L}$ $\quad n = ?$

solution: $n = CV$

$= 0.320\ \text{mol/L} \times 0.0450\ \text{L}$

$= 0.0144\ \text{mol}\ \ (3\ \text{significant digits})$

c. **Unit Analysis Method**

Find the molar mass of sodium sulphate.

$$\text{molar mass} = \left[(2 \times 22.99) + 32.06 + (4 \times 16.00)\right] \text{g/mol}$$
$$= 142.04\ \text{g/mol}$$

(1 mark)

Formula Method

solution: $M = \left[(2 \times 22.99) + 32.06 + (4 \times 16.00)\right] \text{g/mol}$

$= 142.04\ \text{g/mol}$

d. **Unit Analysis Method**

Convert mL to L.

$$25.0\ \cancel{\text{mL}} \times \frac{1\ \text{L}}{1000\ \cancel{\text{mL}}} = 0.0250\ \text{L}$$

Calculate the number of moles of sodium sulphate.

$$\frac{1.50\ \text{mol}}{1\ \cancel{\text{L}}} \times 0.0250\ \cancel{\text{L}} = 0.0375\ \text{mol}\ \ (3\ \text{significant digits})$$

(2 marks)

Formula Method

data: $V = 25.0\ \text{mL} = 0.0250\ \text{L}$ $\quad c = 1.50\ \text{mol/L}$ $\quad n = ?$

solution: $n = CV$

$= 1.50\ \text{mol/L} \times 0.0250\ \text{L}$

$= 0.0375\ \text{mol}\ \ (3\ \text{significant digits})$

e. **Unit Analysis Method**

Calculate mass of sodium sulphate.

$$0.0375\ \cancel{\text{mol}} \times \frac{142.04\ \text{g}}{1\ \cancel{\text{mol}}} = 5.33\ \text{g}\ \ (3\ \text{significant digits})$$

(2 marks)

Formula Method

data: $M = 142.04\ \text{g/mol}$ $\quad n = 0.0375\ \text{mol}$ $\quad m = ?$

solution: $m = nM$

$= 0.0375\ \text{mol} \times 142.04\ \text{g/mol}$

$= 5.33\ \text{g}\ \ (3\ \text{significant digits})$

f. **Unit Analysis Method**

Find the molar mass of alumunum nitrate.

$$\text{molar mass} = \left[26.98 + (3 \times 14.01) + (9 \times 16.00)\right] \text{g/mol}$$
$$= 213.01\ \text{g/mol}$$

(1 mark)

Formula Method

solution: $M = \left[26.98 + (3 \times 14.01) + (9 \times 16.00)\right] \text{g/mol}$

$= 213.01\ \text{g/mol}$

g. **Unit Analysis Method**

Calculate the number of moles of aluminum nitrate.

$$4.00\ \text{g} \times \frac{1\ \text{mol}}{213.01\ \text{g}} = 0.0188\ \text{mol}\ \ (3\ \text{significant digits})$$

(2 marks)

Formula Method

data: $M = 213.01\ \text{g/mol}$ $\quad m = 4.00\ \text{g}$

$n = ?$

solution: $n = \dfrac{m}{M}$

$= \dfrac{4.00\ \text{g}}{213.01\ \text{g/mol}}$

$= 0.0188\ \text{mol}\ \ (3\ \text{significant digits})$

h. **Unit Analysis Method**

Convert mL to L.

$$100\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} = 0.100\ \text{L}$$

Calculate concentration of aluminum nitrate.

$$\text{concentration} = 0.0188\ \text{mol} \times \frac{1}{0.100\ \text{L}}$$

$$= 0.188\ \text{mol/L}\ \ (3\ \text{significant digits})$$

(2 marks)

Formula Method

data: $V = 100\ \text{mL}$ $\quad n = 0.0188\ \text{mol}$

$= 0.100\ \text{L}$ $\quad C = ?$

solution: $C = \dfrac{n}{V}$

$= \dfrac{0.0188\ \text{mol}}{0.100\ \text{L}}$

$= 0.188\ \text{mol/L}\ \ (3\ \text{significant digits})$

4. a. The materials are as follows:

- 25.0 mL volumetric flask or graduated cylinder
- stirring rod
- rinse bottle (optional)
- 50 mL beaker
- distilled water

(2 marks)

b. The procedure is as follows:

Step 1: Dissolve the 0.325 g of $CoCl_{2(s)}$ in about 10 mL of water in the beaker.

Step 2: Using a stirring rod to help guide the solution, pour the $CoCl_{2(aq)}$ into the 25 mL volumetric flask or graduated cylinder.

Step 3: Rinse the beaker and stirring rod using 3 mL or 4 mL of distilled water.
Step 4: Pour the rinse water into the volumetric flask or graduated cylinder.
Step 5: Add enough water to fill the volumetric flask to the calibration mark or the graduated cylinder to the 25 mL line.
Step 6: Insert the stopper and invert several times or stir the solution in the graduated cylinder with the stirring rod.
(3 marks)

5. a. $C_1V_1 = C_2V_2$

$$V_1 = \frac{C_2V_2}{C_1}$$

$$= \frac{0.250\ \text{L} \times 0.50\ \text{mol/L}}{3.00\ \text{mol/L}}$$

$$= 0.042\ \text{L}$$

$$= 42\ \text{mL}\ \ (2\ \text{significant digits})$$

42 mL of the concentrated solution is needed for the dilution. **(2 marks)**

b. The procedure is as follows:

Step 1: Using a 50 mL graduated cylinder, transfer 42 mL of the 3.00 mol/L solution into a 250 mL volumetric flask or a 250 mL graduated cylinder. (You can also use a calibrated pipette.)

Step 2: Add distilled water until the calibration mark or the 250 mL level is reached.

Step 3: Insert the stopper and invert the volumetric flask several times. If you are using a graduated cylinder, use a stirring rod to mix the solution.

(3 marks)

6. a. Either one of the following two methods is acceptable.

Unit Analysis Method

Find the molar mass of PCP.

$$\text{molar mass} = [(6\times 12.01)+(5\times 35.45)+16.00+1.01]\,\text{g/mol}$$
$$= 266.32\,\text{g/mol}$$

Calculate the number of moles of PCP.

$$1000\,\text{g}\times\frac{1\,\text{mol}}{266.32\,\text{g}} = 3.754\,88\,\text{mol}$$

Calculate the concentration of PCP.

$$3.754\,88\,\text{mol}\times\frac{1}{1000\,\text{L}} = 0.003\,755\,\text{mol/L}$$

(4 significant digits)

Formula Method

data: $m = 1000\,\text{g}$

$M = [(6\times 12.01)+(5\times 35.45)+16.00+1.01]\,\text{g/mol}$
$= 266.32\,\text{g/mol}$

$V = 1000\,\text{L}$

$n = ?$

$c = ?$

solution: $n = \frac{m}{M}$

$= \frac{1000\,\text{g}}{266.32}$

$= 3.754\,88\,\text{mol}$

$C = \frac{n}{V}$

$= \frac{3.754\,88\,\text{mol}}{1000\,\text{L}}$

$= 0.003\,755\,\text{mol/L}$

(4 significant digits)

In terms of moles per litre, the concentration is approximately 0.003 755 mol/L. **(3 marks)**

b. The risks are as follows:

- The bacteria method will take too long because of the slow down in the winter.
- The method may not work and the soil may need to be hauled away anyway.

The benefits are as follows:

- This method is cheaper by approximately 25%.
- Only the site is contaminated. Trucking the soil may contaminate other locations on the way to the incinerator or waste disposal plant.
- The equipment used to haul the soil will be difficult to clean afterwards.
- This may make hauling the contaminated soil safer if it does not reduce the PCP contamination completely.
- This method could potentially recover the land without destroying the topsoil.

The number of benefits is definitely greater than the number of risks. If laboratory trials of the bacteria method prove successful on a small scale, it would definitely be worthwhile trying on the large scale. **(6 marks)**

Section 3: Stoichiometry – Using Chemical Equations

Key Concepts

- Stoichiometry involves calculating masses of chemicals involved in chemical reactions.
- Theoretical yield is calculated from an equation; actual yield is obtained from a lab investigation.
- Percent yield is found by relating the actual yield to the theoretical yield.

Teaching Suggestions

Section 3 deals with laboratory skills and calculation skills related to stoichiometry.

Students are expected to have previous knowledge of working with significant digits, calculating molar masses, and recognizing some common formulas.

The answers in the Appendix are shown with the significant digits being carried and rounding off of measurements after the last calculation. The intermediate steps are shown as rounded but the display on a calculator to ten digits is actually carried to the final step.

The lab and how it relates is very important to the concept of stoichiometry. If there is time, another lab can be done to supplement the investigation.

Section 3: Assignment Answer Key (35 marks)

1.

				a. M	A	S	**S**									
b. M	O	L	E		R	A	**T**	I	O							
					c. P	R	**O**	D	U	C	T					
			d. F	E	R	T	**I**	L	I	Z	E	R	S			
	e. C	O	E	F	F	I	**C**	I	E	N	T	S				
						f. T	**H**	E	O	R	E	T	I	C	A	L
		g. A	M	M	O	N	**I**	A								
						h. S	**O**	L	U	T	E					
							i. **M**	O	L	E						
	j. B	A	L	A	N	C	**E**									
	k. P	E	R	C	E	N	**T**									
			l. M	O	L	A	**R**		M	A	S	S				
							m. **Y**	I	E	L	D					

(6 marks)

2. a. $2.30 \text{ mol} \times \frac{2 \text{ mol of } N_{2(g)}}{4 \text{ mol of } NH_{3(g)}} = 1.15 \text{ mol of } N_{2(g)}$ **(1 mark)**

b. $1.7 \text{ mol} \times \frac{6 \text{ mol of } H_2O_{(g)}}{3 \text{ mol of } O_{2(g)}} = 3.4 \text{ mol of } H_2O_{(g)}$ **(1 mark)**

c. $0.0350 \text{ mol} \times \frac{3 \text{ mol of } O_{2(g)}}{2 \text{ mol of } N_{2(g)}} = 0.0525 \text{ mol of } O_{2(g)}$ **(1 mark)**

3. a. **Unit Analysis Method**

Calculate the number of moles of $N_{2(g)}$.

$$\text{molar mass} = 2 \times 14.01 \text{ g/mol}$$
$$= 28.02 \text{ g/mol}$$

$$150 \text{ g} \times \frac{1 \text{ mol}}{28.02 \text{ g}} = 5.3533 \text{ mol}$$

Calculate the number of moles of $NH_{3(g)}$.

$$5.3533 \text{ mol} \times \frac{2 \text{ mol of } NH_{3(g)}}{1 \text{ mol of } N_{2(g)}} = 10.707 \text{ mol}$$

Calculate the mass of $NH_{3(g)}$.

$$\text{molar mass} = \left[14.01 + (3 \times 1.01)\right] \text{g/mol}$$
$$= 17.04 \text{ g/mol}$$

$$10.707 \text{ mol} \times \frac{17.04 \text{ g}}{1 \text{ mol}} = 182 \text{ g (3 significant digits)}$$

The theoretical yield is about 182 g. **(4 marks)**

Formula Method

data:

$1N_{2(g)}$	$2NH_{3(g)}$
$M = 2 \times 14.01 \text{ g/mol}$ $= 28.02 \text{ g/mol}$	$M = \left[14.01 + (3 \times 1.01)\right] \text{g/mol}$ $= 17.04 \text{ g/mol}$
$m = 150 \text{ g}$	$m = ?$

solution:

$$n = \frac{m}{M} = \frac{150 \text{ g}}{28.02 \text{ g/mol}}$$
$$= 5.3533 \text{ mol}$$

$$5.3533 \text{ mol} \times \frac{2 \text{ mol of } NH_{3(g)}}{1 \text{ mol of } N_{2(g)}} = 10.707 \text{ mol}$$

$$m = nM = 10.707 \text{ mol} \times 17.04 \text{ g/mol}$$
$$= 182 \text{ g (3 significant digits)}$$

b. $$\%\text{yield} = \frac{\text{actual mass}}{\text{predicted mass}} \times 100$$
$$= \frac{175 \text{ g}}{182 \text{ g}} \times 100$$
$$= 96.2\% \text{ (3 significant digits)}$$ **(1 mark)**

If the digits are carried through and then rounded, then 95.9% rounded to three significant digits is also correct.

4. a. The materials are as follows:

- silver nitrate solution, $AgNO_{2(aq)}$
- sodium sulphate solution, $Na_2SO_{4(aq)}$
- beakers
- distilled water
- filter paper
- graduated cylinder
- stirring rod
- funnel
- watch glass
- balance

(2 marks)

The procedure is as follows:

Step 1: Measure 1.00 g of sodium sulphate using a balance, and dissolve in 50 mL of water.

Step 2: Add 50.0 mL of silver nitrate solution.

Step 3: Stir and allow the precipitate to settle.

Step 4: Use an eye dropper to add about 10 additional drops of $AgNO_3$ solution. If you see anymore precipitate forming, continue to add $AgNO_3$ solution until you see no more precipitate forming.

Step 5: Measure the mass of the filter paper.

Step 6: Filter the mixture and allow the filter paper and the precipitate to completely dry on a watch glass.

Step 7: Measure the mass of the filter paper and the dried precipitate.

Step 8: Subtract the mass of the filter paper from the mass of the filter paper and dried precipitate.
(4 marks)

b. The balanced chemical equation is as follows:

$$Na_2SO_{4(aq)} + 2AgNO_{3(aq)} \rightarrow Ag_2SO_{4(s)} + 2NaNO_{3(aq)}$$

Unit Analysis Method

Calculate the number of moles of $Na_2SO_{4(aq)}$.

$$\text{molar mass} = \left[(2\times 22.99) + 32.06 + (4\times 16.00)\right] \text{g/mol}$$
$$= 142.04 \text{ g/mol}$$

$$1.00 \text{ g} \times \frac{1 \text{ mol}}{142.04 \text{ g}} = 0.007\,0403 \text{ mol}$$

Calculate the number of moles of $Ag_2SO_{4(s)}$.

$$0.007\,0403 \text{ mol} \times \frac{1 \text{ mol of } Ag_2SO_{4(s)}}{1 \text{ mol of } Na_2SO_{4(aq)}} = 0.007\,0403 \text{ mol}$$

Calculate the mass of $Ag_2SO_{4(s)}$.

$$\text{molar mass} = \left[(2\times 107.87) + 32.06 + (4\times 16.00)\right] \text{g/mol}$$
$$= 311.80 \text{ g/mol}$$

$$0.007\,0403 \text{ mol} \times \frac{311.80 \text{ g}}{1 \text{ mol}} = 2.20 \text{ g} \text{ (3 significant digits)}$$

Formula Method

data:

$1Na_2SO_{4(aq)}$	$1Ag_2SO_{4(s)}$
$M = [(2\times14.01)+32.06+(4\times16.00)]\ g/mol$ $= 142.04\ g/mol$	$M = [(2\times107.87)+32.06+(2\times16.00)]\ g/mol$ $= 311.80\ g/mol$
$m = 1.00\ g$	$m = ?$

solution:

$$n = \frac{m}{M} = \frac{1.00\ g}{142.04\ g/mol}$$
$$= 0.007\,0403\ mol$$

$$0.007\,0403\ mol \times \frac{1\ mol\ of\ Ag_2SO_{4(s)}}{1\ mol\ of\ Na_2SO_{4(aq)}} = 0.007\,0403\ mol$$

$$m = nM = 0.007\,0403\ mol \times 311.80\ g/mol$$
$$= 2.20\ g\ (3\ significant\ digits)$$

The mass of the precipitate is approximately 2.20 g. **(4 marks)**

c. $$\%\ yield = \frac{actual\ mass}{predicted\ mass}$$
$$= \frac{2.30\ g}{2.20\ g} \times 100$$
$$= 105\%$$

(2 marks)

d. The experiment is judged to be valid with the actual yield being very close to the theoretical yield (within 5%). The sources of error could include the following:

- precipitate not completely dry
- measurement inaccuracies
- reaction not complete
- Ag_2NO_3 was impure
- other reactions involved

5. a. $3NO_{2(g)} + 1H_2O_{(l)} \rightarrow 2HNO_{3(l)} + 1NO_{(g)}$ **(1 mark)**

b. $M = [1.01+14.01+(3\times16.00)]\ g/mol$
$= 63.02\ g/mol$

$m = nM = 0.635\ mol \times 63.02\ g/mol$
$= 40.0\ g\ (3\ significant\ digits)$

The mass of nitric acid formed is about 40.0 g. **(2 marks)**

c. **Unit Analysis Method**

Calculate the number of moles of $NO_{2(g)}$.

$$\text{molar mass} = [14.01 + (2 \times 16.00)]\ \text{g/mol}$$
$$= 46.01\ \text{g/mol}$$

$$100\ \text{g} \times \frac{1\ \text{mol}}{46.01\ \text{g}} = 2.1734\ \text{mol}$$

Calculate the number of moles of $HNO_{3(l)}$.

$$2.1734\ \text{mol} \times \frac{2\ \text{mol of } HNO_{3(l)}}{3\ \text{mol of } NO_{2(g)}} = 1.4490\ \text{mol}$$

Calculate the mass of $HNO_{3(l)}$.

$$\text{molar mass} = [1.01 + 14.01 + (3 \times 16.00)]\ \text{g/mol}$$
$$= 63.02\ \text{g/mol}$$

$$1.4490\ \text{mol} \times \frac{63.02\ \text{g}}{1\ \text{mol}} = 91.3\ \text{g (3 significant digits)}$$

$$\%\text{yield} = \frac{40.0\ \text{g}}{91.3\ \text{g}} \times 100$$
$$= 43.8\%$$

The percent yield of this reaction is approximately 43.8%. **(4 marks)**

Formula Method

data:

$3NO_{2(g)}$	$2HNO_{3(l)}$
$M = 14.01 + (2 \times 16.00)$ $= 46.01\ \text{g/mol}$	$M = 1.01 + 14.01 + (3 \times 16.00)$ $= 63.02\ \text{g/mol}$
$m = 100\ \text{g}$	$m = ?$

solution:

$$n = \frac{m}{M} = \frac{100\ \text{g}}{46.01\ \text{g/mol}}$$
$$= 2.1734\ \text{mol}$$

$$2.1734\ \text{mol} \times \frac{2\ \text{mol of } HNO_{3(l)}}{3\ \text{mol of } NO_{2(g)}} = 1.4490\ \text{mol}$$

$$m = nM = 1.4490\ \text{mol} \times 63.02\ \text{g/mol}$$
$$= 91.3\ \text{g (3 significant digits)}$$

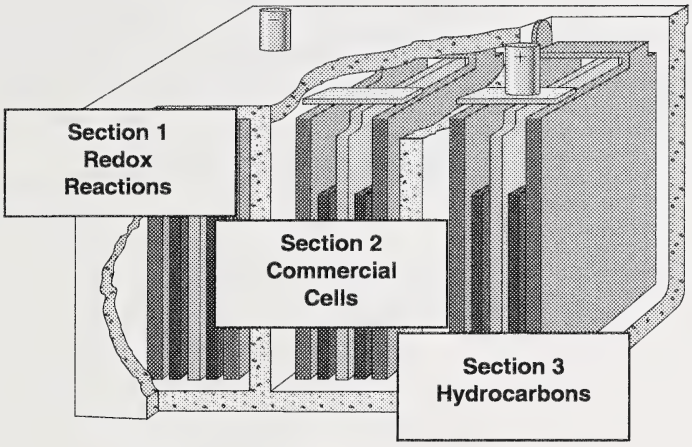
Module 6: Applications of Chemistry

Overview

This module deals with oxidation-reduction reactions (redox reactions) and hydrocarbons and their application to everyday life and industry. In Section 1 the activity series and redox reactions are introduced. Students learn why some metals react with each other and others do not. In Section 2 students learn how redox reactions are applied commercially in electrochemical cells (batteries) and electrolytic cells. In Section 3 students are introduced to organic chemistry and learn how to name a number of different groups of hydrocarbons. Some of the reactions these groups undergo are studied. The importance of the petroleum industry in Alberta is looked at in terms of production of chemicals for the plastics industry.

Students are asked to perform investigations which attempt to teach them organizational, analytical, and synthesizing skills. Answers are provided for the questions in the Appendix of the Module Booklet. Students may submit their Enrichment activities to their learning facilitator for confirmation.

Module 6
Applications of Chemistry



Evaluation

The evaluation of this module is based on three assignments.

Section 1 Assignment	**25 marks**
Section 2 Assignment	**35 marks**
Section 3 Assignment	**40 marks**
TOTAL	**100 marks**

Materials and Equipment

The following is a list of materials needed to complete the investigations and activities in this module. Amounts stated represent requirements per student.

Section 1: Activity 1

Investigation: Investigating the Activity Series

Part A

- test tubes (or 25 mL beakers)
- 0.2 mol/L solutions of:
  - zinc nitrate, $Zn(NO_3)_{2(aq)}$
  - silver nitrate, $AgNO_{3(aq)}$
  - copper (II) nitrate, $Cu(NO_3)_{2(aq)}$
- solid zinc, $Zn_{(s)}$
- solid silver, $Ag_{(s)}$
- solid copper, $Co_{(s)}$
- steel wool
- distilled water

Part B

Data results are provided in the Observations section.

Section 1: Activity 2

Investigation: Studying Corrosion and Its Prevention

Part A

- 6 beakers (250 mL or 100 mL)
- 2 mason jars with seal rings and lids
- tongs, pot holders, or oven mitts
- large pot of water
- hotplate
- 4 untreated nails
- 4 galvanized nails
- 2 pieces of metal cut from food or juice cans
- tap water
- sodium chloride ($NaCl_{(s)}$)

Part B

- strips of copper, zinc, and silver
- 3 untreated nails
- 0.7 mol/L sodium chloride solution, $NaCl_{(aq)}$
- insulated copper wires with alligator clips at the ends

Section 2: Activity 1

Investigation: Building a Galvanic Cell

Part A

- strips of copper, zinc, and magnesium
- 1.0 mol/L solutions of:
  - copper(II) sulphate, $CuSO_{4(aq)}$
  - zinc sulphate, $ZnSO_{4(aq)}$
  - magnesium sulphate, $MgSO_{4(aq)}$
- salt bridge or porous cup
- voltmeter
- alligator clips and insulated copper wire
- steel wool
- beakers

The following are suggestions for completing this investigation.

- A U-tube can be used to make a salt bridge. Plug the ends with cotton batton or paper towels.
- Use an electrolyte which does not interfere with the reaction such as sodium nitrate $\left(Na_2NO_{3(aq)}\right)$ or potassium nitrate $\left(KNO_{3(aq)}\right)$.
- A porous cup can be used in place of the U-tube and the beakers.
- The alligator clips should not be in the solution.

Part B

- TV Ontario video entitled *Electrochemistry: Electrochemical Cells*, ACCESS Network, available from Learning Resources Distributing Centre
- *Visions 2*
- data results in the Observations section

Section 2: Activity 2

Investigation: Building an Electrolytic Cell

- U-tube
- 2 carbon rods
- stand with clamp
- eyedropper
- litmus paper
- 2 insulated copper wires with alligator clips at both ends
- power source (use a power pack)
- 50 mL of 1.0 mol/L potassium iodide solution, $KI_{(aq)}$
- watch glass

The following are suggestions for completing this investigation.

- The concentration of the $KI_{(aq)}$ should be 1.0 mol/L.
- Graphite electrodes are suggested.
- Point out to the students that the bubbles coming out are hydrogen gas. Ask how they can test for it.
- Changing the output of the power source will change the rate of the reaction as well. Demonstrate this and ask why this happens.
- All chemicals should be discarded in appropriate containers.

Section 3: Activity 1

Investigation: Investigating the Combustion Property of a Hydrocarbon

Part A

- bunsen burner
- candle
- matches
- 2 glass test tubes
- cold water

Part B

- candle
- matches
- 2 glass test tubes
- cold water

Section 3: Activity 4

Investigation: Comparing Plastics

- samples of polyethylene, polypropylene, cellulose acetate (overhead film), nylon, acrylic, polystryrene
- container of water
- HB pencil

The following are required only if students are heating the samples in a fume hood or outside.

- bunsen burner (or candle)
- wire gauze
- copper wire
- safety glasses
- retort stand
- evaporating dish or metal lid
- fume hood

The following are suggestions for completing this investigation.

- Refer to page 353 of *Visions 2* for examples of materials made from the various types of plastics.
- All steps requiring heating the polymer must be carried out in a fume hood.
- Students may need help in preparing the observation chart and following through Figure 9.13. The learning facilitator may want to use one sample as a demonstration and go through Figure 9.13 with the students.

Additional Resources

Basic Organic Chemistry, Wiseman, Frank L., McGraw-Hill Book Company, 1988.
Modern Chemistry, Metcalf, Williams, and Castka, Holt, Rinehart, and Winston Publishers, 1978.
Fundamentals of Chemistry, Reidmore, Prentice-Hall Inc., 1979.

Mandatory Videos

Section 2: Activity 1

Electrochemistry: Electrochemical Cells, TV Ontario, ACCESS Network, 1986, available from Learning Resources Distributing Centre.

Section 1: Activity 2

Electrochemistry: Electroplating, TV Ontario, ACCESS Network, 1986, available from Learning Resources Distributing Centre.

Optional Videos

Section 1: Activity 2

Electrochemistry: Corrosion, TV Ontario, ACCESS Network, 1986.

Section 3: Activity 1

Organic Chemistry 1, TV Ontario, ACCESS Network, 1989.

Section 3: Activity 2

Organic Chemistry 1, TV Ontario, ACCESS Network, 1987.

Section 3: Activity 4

Organic Chemistry 1, TV Ontario, ACCESS Network.

Another video which may be used with this module is as follows:

World of Chemistry, Polymers, Magic Lantern Communications Ltd.

Section 1: Redox Reactions

Key Concepts

- Redox reactions involve the transfer of electrons.
- Oxidation is a loss of electrons.
- Reduction is a gain of electrons.
- Metals and metal ions have a particular order of reactivity.
- Corrosion is a redox reaction.
- Corrosion can be prevented by coating, galvanization, plating, and sacrificial protection.

Section 1: Assignment Answer Key (25 marks)

1. The reactions which will occur are A, C, and E. This is because the free metal is more reactive than the ion in the solution and will give up its electron readily to the ions with which they are reacting.

   Give one mark for each correct reaction picked and 2 marks for the explanation. **(5 marks)**

2. The arrangement in decreasing order of reactivity is iron, tin, and lead. **(2 marks)**

3. a. Magnesium is more reactive than iron. Therefore, when magnesium turnings are connected to an iron pipe, the turnings will become oxidized instead of the iron. This will prevent the corrosion of the iron pipeline. **(1 mark)**

   b. The name given to this method of corrosion prevention is sacrificial protection. **(1 mark)**

   c. Zinc can be used instead of magnesium. Note: There are other metals that are more reactive than iron but they are not suitable for sacrificial protection for various reasons. **(1 mark)**

4. The substances that will resist corrosion are as follows:

   Aluminum – forms a layer of aluminum oxide on its surface which protects it from further corrosion
   Gold – less reactive than most metals and does not react with air and moisture
   Tin – will also form a protective coating of its oxide which will prevent further oxidation
   Stainless steel – contains nickel and chromium along with carbon which makes it resistant to corrosion **(8 marks)**

5. a. The descending order of reactivity is C, A, D, E, and B. **(5 marks)**

   b. No reaction will take place. This is because B is less reactive than C. The free metal (B) will not be able to replace the ion of C in the reaction. **(2 marks)**

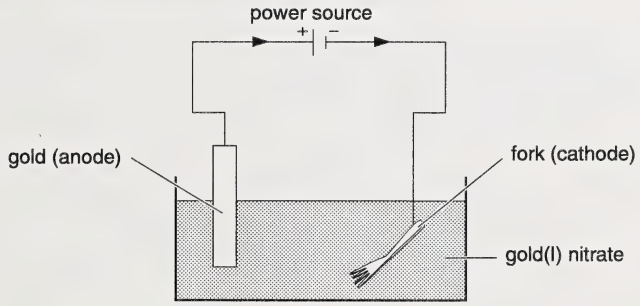
Section 2: Commercial Cells

Key Concepts

- Spontaneous redox reactions produce electricity.
- Batteries are the result of spontaneous redox reactions.
- Electrolytic cells require electricity to drive their reactions to completion.
- Electrolytic cells are used for the extraction of metals and electroplating.

Section 2: Assignment Answer Key (35 marks)

1. Students can use any soluble salt of gold like gold(I) nitrate or gold(I) sulphate. **(6 marks)**



2. a. Mg and Ag **(1 mark)**

   b. The reduction half-reaction is $Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)}$. **(1 mark)**

   The oxidation half-reaction is $Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^{-}$. **(1 mark)**

   c. The oxidation half-reaction $\left(Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^{-}\right)$ occurs at the anode, and reduction half-reaction $\left(Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)}\right)$ occurs at the cathode. The anode (magnesium strip) will have mass loss. **(2 marks)**

   d. The paper soaked with NaCl replaces the salt bridge to allow ion flow. **(2 marks)**

   e. The anode is the magnesium and the cathode is the silver. **(1 mark)**

3. a. A represents zinc. B represents zinc sulphate. C represents nickel. D represents nickel nitrate. **(2 marks)**

   b. At A, the half-reaction is $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^{-}$. At C, the half-reaction is $Ni^{2+}_{(aq)} + 2e^{-} \rightarrow Ni_{(s)}$. **(2 marks)**

c. The overall equation is $Zn_{(s)} + Ni^{2+}{}_{(aq)} \rightarrow Zn^{2+}{}_{(aq)} + Ni_{(s)}$. **(2 marks)**

d. This is an electrochemical cell or a galvanic cell or a voltaic cell. **(1 mark)**

e. Zinc (A) is the anode and nickel (C) is the cathode. **(1 mark)**

f. The porous cup is a ceramic cup which allows ions to flow through but prevents the mixing of the electrolytes. **(2 marks)**

4. An electrochemical cell can be made from $Mg_{(s)}$ and $Cu^{2+}{}_{(aq)}$, $Cu_{(s)}$ and $Ag^{+}{}_{(aq)}$, $Fe_{(s)}$ and $H^{+}{}_{(aq)}$, and $Br_{2(aq)}$ and $Fe^{2+}{}_{(aq)}$. These can be used to make electrochemical cells because spontaneous reactions occur since, in each case, the solid metal is more reactive than the metal ion.

   Give two marks for the choices and three marks for the explanation. **(5 marks)**

5. A galvanic cell produces an electric current from a spontaneous chemical reaction, while an electrolytic cell requires an electric current to drive a chemical reaction to completion resulting in a chemical change. **(3 marks)**

6. The main types of batteries are acid batteries and alkaline batteries. Batteries used in vehicles are examples of acid batteries and flashlight batteries are examples of alkaline batteries. **(3 marks)**

Section 3: Hydrocarbons

Key Concepts

- Hydrocarbons are organic compounds containing carbon and hydrogen.
- Oil and natural gas are the main natural sources of hydrocarbons.
- Both molecular and structural formulas are used to represent hydrocarbons.
- Special rules for naming hydrocarbons have been established.
- Three families of hydrocarbons are alkanes, alkenes, and alkynes.
- Alkanes have only single carbon-carbon bonds and are termed saturated.
- Alkenes and alkynes have double and triple carbon-carbon bonds and are termed unsaturated.
- Alkanes undergo substitution reactions while alkenes and alkynes undergo addition and substitution reactions.
- Polymers are hydrocarbons which are produced by joining repeating units of smaller molecules.
- Plastics are an important example of polymers, and are used in hundreds of products.

Section 3: Assignment Answer Key (40 marks)

1. a. Compounds A, B, and F belong to the alkane family. Compound C is an alkene. Compounds D and E belong to the alkyne family. **(2 marks)**

   b. A. pentane
   B. 2-methylbutane
   C. 4-methyl-1-pentene
   D. 2-pentyne
   E. 2,5-dimethyl-3-heptyne
   F. 2,5-dimethylhexane
   (6 marks)

   c. Compounds A and B are isomers. They are called isomers because they have the same number of carbon and hydrogen atoms (same molecular formula) but different structures. **(1 mark)**

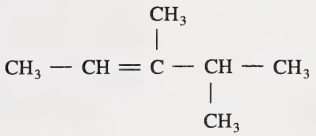
   d. Compounds C, D, and E are unsaturated. These compounds are called unsaturated because they have double or triple bonds. **(1 mark)**

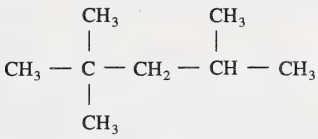
2. The structural diagrams are as follows:

a.

(1 mark)

b. $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$
(1 mark)

c.

(2 marks)

d.

(2 marks)

3. a. $2C_3H_{6(g)} + 9O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$ **(1 mark)**

b. $CH_3 - CH = CH_{2(g)} + Br_{2(l)} \rightarrow CH_3 - CH_2 - CHBr$ **(1 mark)**

c. The name of the polymer is polypropene (polypropylene). **(1 mark)**

4. A method used to separate mixtures of substances is called fractional distillation. First hydrocarbons are heated until they crack to produce a mixture of small-chained hydrocarbons. These molecules have different boiling points and can be separated by having the vapours move upward through a fractionating tower. The fractions condense at their respective temperatures with the heavier ones condensing in the lower compartments and the lighter ones condensing at the top. **(4 marks)**

5. a. Fraction X is gasoline. **(1 mark)**

b. Molecules of Fraction Z are the longest. **(1 mark)**

6. The process of catalytic reforming converts straight-chained hydrocarbons to branched hydrocarbons. Catalytic reforming is used to produce high-grade gasoline from low-grade gasoline and to provide raw materials for the production of petrochemicals. **(3 marks)**

7. a. Ethene, styrene, and bromopropene can be used to make polymers. This is because they have a double bond which can open up to undergo addition reactions. **(3 marks)**

b. The names of the polymers would be ethylene or polyethene, polystyrene, and bromopropylene. **(3 marks)**

8. A disadvantage of plastics is that they are a hazard to the Earth's environment because they are not biodegradable. Advantages of plastics are that they are light, easy to produce, and do not conduct electricity. **(2 marks)**

9. a. The special property of thermoplastic polymers is that they can be reheated and shaped several times. Thermoplastic polymers include ethylene, PVC, nylon, terylene, polystyrene, and glass. **(2 marks)**

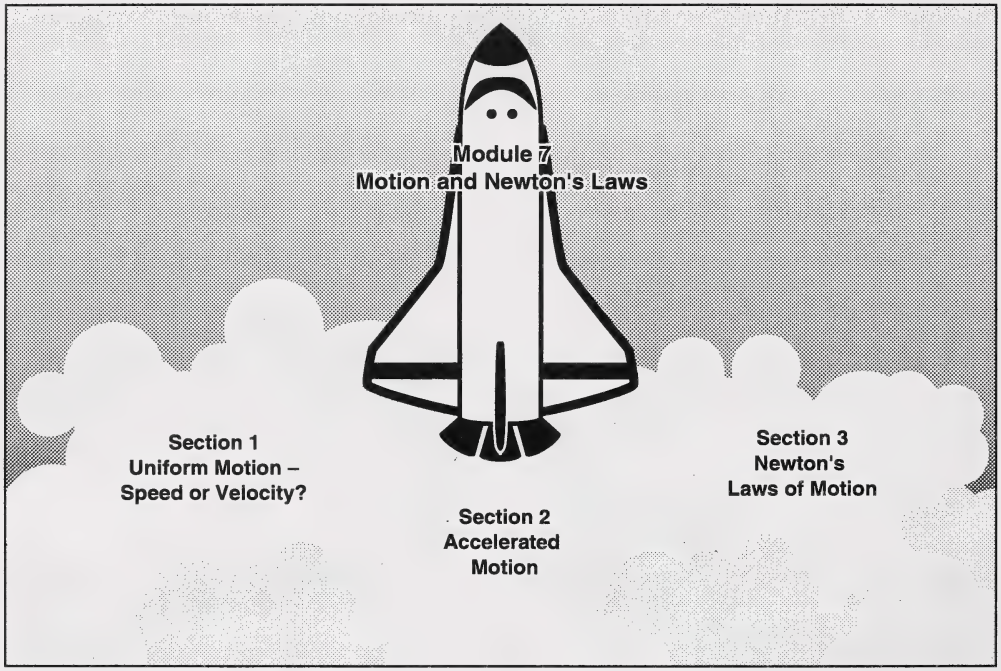
b. The special property of thermosets is that they can be heated only once to shape. Examples of thermosets include Bakelite™, Formica™, varnishes, alkyds, and ebonite. **(2 marks)**

Module 7: Motion and Newton's Laws

Overview

This module essentially introduces the science student to a fundamental glance at the science of mechanics. Sections 1 and 2 deal with the study of kinematics. Section 1 concentrates on a mathematical and graphical analysis of uniform motion, and Section 2 concentrates on a mathematical and graphical analysis of accelerated motion. Section 3 deals with a study of dynamics, where students are introduced to Newton's three laws of motion.

After completing this module, students should be better prepared to analyse, qualitatively and quantitatively, the motions and the causes of motions of all objects in the universe in which they live.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**30 marks**
Section 2 Assignment	**30 marks**
Section 3 Assignment	**40 marks**
Total	**100 marks**

Materials and Equipment

Section 1: Activity 3

Investigation: Uniform Motion – Review

- ticker tape results (given in Observations section)
- ruler (given in Appendix)
- graph paper

Investigation: Uniform Motion in Two Directions

- diagrammatic representation of photographs of a moving billiard ball
- ruler (given in Appendix)
- graph paper

Section 2: Activity 1

Investigation: Identifying Accelerated Motion

- audiotape (beeps 1 s apart)
- long, smooth table or a sheet of plywood (about 2 m in length)
- small steel ball
- computer paper (about 2 m in length)
- ruler or metre stick
- felt pen or pencil

Section 2: Activity 2

Investigation: Mathematical Analysis of Uniform Accelerated Motion (Using Given Data)

- data chart provided in Procedure section or your own results from the investigation in Activity 1
- graph paper

Section 2: Activity 4

Investigation: The Acceleration of Free Fall

Part A

- ticker tape timer with battery (frequency of 40 Hz)
- ticker tape (at least 2 m in length)
- C-clamp
- 50 g mass
- metre stick
- stopwatch
- table or shelf at least 2 m above floor
- masking tape

Part B

- ticker tape data provided in the Appendix
- graph paper
- pencil and paper

Section 3: Activity 2

Investigation: Factors Affecting Acceleration of an Object

Part A

- ticker tape timer (set at $\frac{1}{10}$ s)
- ticker tape
- long table
- rolling dynamics cart
- triple beam balance or scale
- three masses (50 g, 100 g, and 150 g)
- various additional masses (200 g, 500 g)
- string
- pulley
- tape

Part B

Note: The same materials are used for both Parts A and B of this investigation. Students who do not have access to these materials will complete the questions using the sample ticker tapes provided in the Observations in each part.

Additional Resources

Zitzewitz, Davids, and Neff, *Merrill Physics: Principles and Problems*, Maxwell MacMillan Canada, 1992.

Martindale, Heath, and Eastman, *Fundamentals of Physics*, D.C. Heath Canada Ltd., 1992.

Mandatory Videos

Section 3: Extra Help

Force and Motion: *Newton's Three Laws*, Abbar Films, ACCESS Network, available from the Learning Resources Distributing Centre.

Optional Videos

Section 3: Activity 1

Inertia, from the *Mechanical Universe* series, ACCESS Network.

Other videos which may be used with this module are as follows:

- *Conceptual Physics*: *Newton's First and Third Laws*, Addison-Wesley, 1987.
- *Physics of Motion*, Classroom Video, Unit C, 9005 Centaurus Circle, Burnaby, B.C., V3J 7N4.
- *Vectors*, Classroom Video, Unit C, 9005 Centaurus Circle, Burnaby, B.C., V3J 7N4

Section 1: Uniform Motion – Speed or Velocity?

Key Concepts

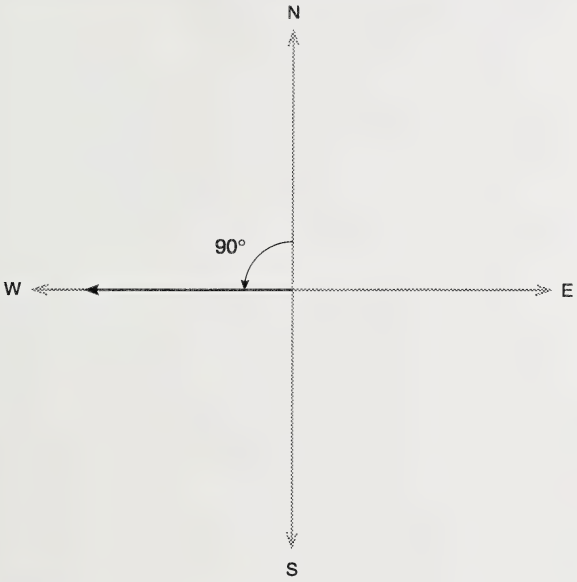
- direction is key to different types of motion
- uniform speed and uniform velocity
- vectors and their application
- graphing uniform motion

Section 1: Assignment Answer Key (30 marks)

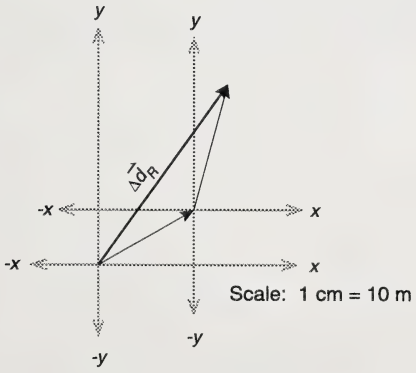
1. a. True. Distance is a scalar quantity; therefore, only magnitude needs to be stated. **(2 marks)**

   b. False. Displacement is a vector quantity; therefore, both magnitude and direction must be given. **(2 marks)**

2. The navigation method measures the angle east or west from north or east or west from south. The mathematical method measures counterclockwise from the x-axis (or 0°). **(2 marks)**

3. 

(2 marks)

4. a. 

$\Delta d = 20\text{ m} + 17\text{ m}$
$= 37\text{ m}$

Length of resultant in the diagram is 3.4 cm.

$$\Delta\vec{d}_R = 3.4\text{ cm} \times \frac{10\text{ m}}{1\text{ cm}}$$
$$= 34\text{ m}, 55° \text{ from the } x\text{-axis}$$

Note: An angle of 54° for $\Delta\vec{d}$ is also acceptable.

The change in distance is 37 m, and the displacement is 34 m, 55° from the x-axis. **(4 marks)**

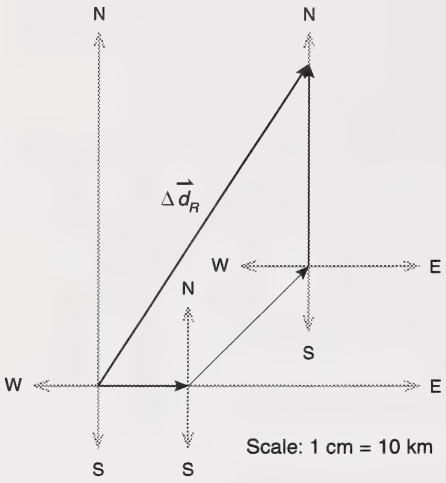
b. Average Speed

$$v_{ave} = \frac{\Delta d}{\Delta t}$$
$$= \frac{37\text{ m}}{10.0\text{ s}}$$
$$= 3.7\text{ m/s}$$ **(2 marks)**

Average Velocity

$$\vec{v}_{ave} = \frac{\Delta \vec{d}}{\Delta t}$$
$$= \frac{34\text{ m}}{10.0\text{ s}}$$
$$= 3.4\text{ m/s, 55° from the } x\text{-axis}$$ **(2 marks)**

5.

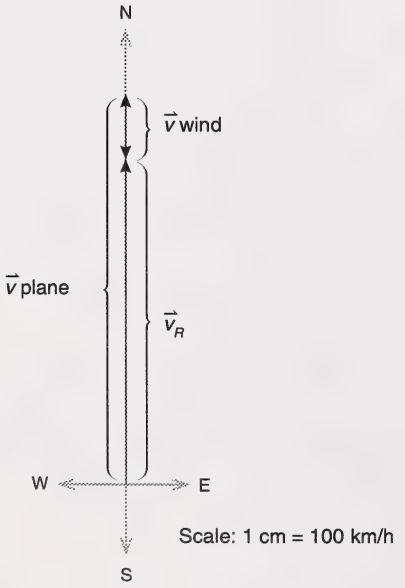


Length of resultant in the diagram is 5.9 cm.

$$\Delta \vec{d}_R = 5.9\text{ cm} \times \frac{10\text{ km}}{1\text{ cm}}$$
$$= 59\text{ km, N33°E}$$

The resultant displacement is 59 km, N33°E. **(3 marks)**

6. a.

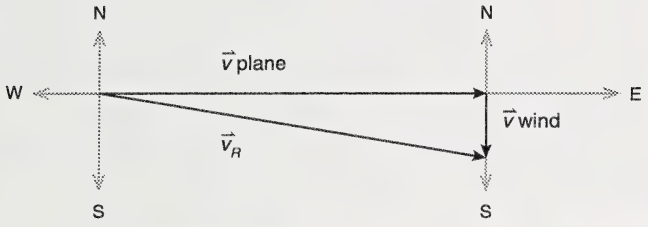


Length of $\vec{v}_R$ in the diagram is 5.0 cm.

$$\vec{v}_R = 5.0\text{ cm} \times \frac{100\text{ km/h}}{1\text{ cm}}$$
$$= 500\text{ km/h, north}$$

The resultant velocity is 500 km/h if the plane heads north. **(2 marks)**

b.



Scale: 1 cm = 100 km/h

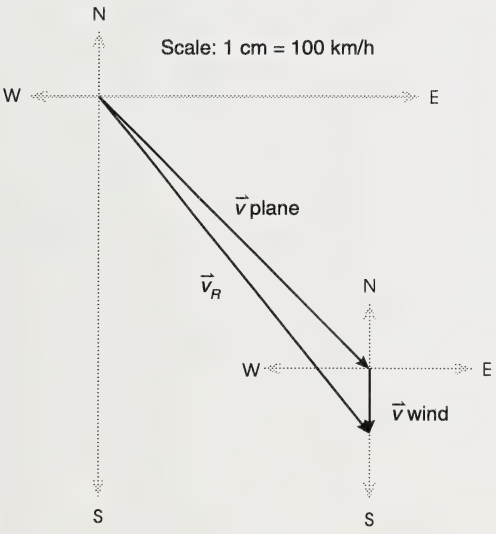
Length of $\vec{v}_R$ in the diagram is 6.1 cm.

$$\vec{v}_R = 6.1 \text{ cm} \times \frac{100 \text{ km/h}}{1 \text{ cm}}$$

$$= 610 \text{ km/h}$$

The resultant velocity is 610 km/h if the plane heads east. **(2 marks)**

c.



Length of $\vec{v}_R$ in the diagram is 6.7 cm.

$$\vec{v}_R = 6.7 \text{ cm} \times \frac{100 \text{ km/h}}{1 \text{ cm}}$$

$$= 670 \text{ km/h}$$

The resultant velocity is 670 km/h if the plane heads S45°E. **(2 marks)**

7. a. $$\text{slope} = \frac{\text{rise}}{\text{run}}$$

$$= \frac{60.0 \text{ cm}}{5.00 \text{ s}}$$

$$= 12.0 \text{ cm/s}$$ **(2 marks)**

b. $$\text{Area under line} = (\text{length} \times \text{width}) + (\text{length} \times \text{width})$$

$$= (\bar{v} \times \Delta t) + (\bar{v} \times \Delta t)$$

$$= (15.0 \text{ m/s} \times 3.00 \text{ s}) + (-10.0 \text{ m/s} \times 2.00 \text{ s})$$

$$= 45.0 \text{ m} + (-20.0 \text{ m})$$

$$= 25.0 \text{ m}$$ **(2 marks)**

The area represents the displacement. **(1 mark)**

Section 2: Accelerated Motion

Key Concepts

- observing accelerated motion
- analysing accelerated motion mathematically
- analysing accelerated motion graphically
- observing acceleration due to gravity (free fall)

Section 2: Assignment Answer Key (30 marks)

1. a. $$\text{total slope} = \frac{\text{total rise}}{\text{total run}}$$
$$= \frac{9.0\text{ cm}}{3.0\text{ s}}$$
$$= 3.0\text{ cm/s}$$ **(2 marks)**

   b. The slope determines the average velocity from $t = 0.0$ s to $t = 3.0$ s. **(1 mark)**

   c. The object has an instantaneous velocity of 3.0 cm/s at the midpoint in time ($t = 1.5$ s). **(1 mark)**

2. a. $$\text{total slope} = \frac{\text{total rise}}{\text{total run}}$$
$$= \frac{6.0\text{ cm/s}}{3.0\text{ s}}$$
$$= 2.0\text{ cm/s}^2$$ **(3 marks)**

   b. The slope determines the acceleration of the object. **(1 mark)**

3. a. $$\text{area under the line} = \frac{1}{2} \times a \times b$$
$$= \frac{1}{2} \times v_{ave} \times \Delta t$$
$$= \frac{1}{2} \times 6.0\text{ cm/s} \times 3.0\text{ s}$$
$$= 9.0\text{ cm}$$ **(3 marks)**

   b. The area under the line determines the total displacement after 3.0 s. **(1 mark)**

4. a. $$\text{area under the line} = 1 \times w$$
$$= \vec{a} \times \Delta t$$
$$= 2.0\text{ cm/s}^2 \times 3.0\text{ s}$$
$$= 6.0\text{ cm/s}$$ **(3 marks)**

   b. The area under the line gives you the change in velocity. **(1 mark)**

5. $\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{\Delta t}$

$= \dfrac{(50.0 \text{ m/s}) - (10.0 \text{ m/s})}{4.00 \text{ s}}$

$= 10.0 \text{ m/s}^2$, north **(3 marks)**

6. a. $\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{\Delta t}$

$= \dfrac{10.0 \text{ m/s} - 50.0 \text{ m/s}}{4.00 \text{ s}}$

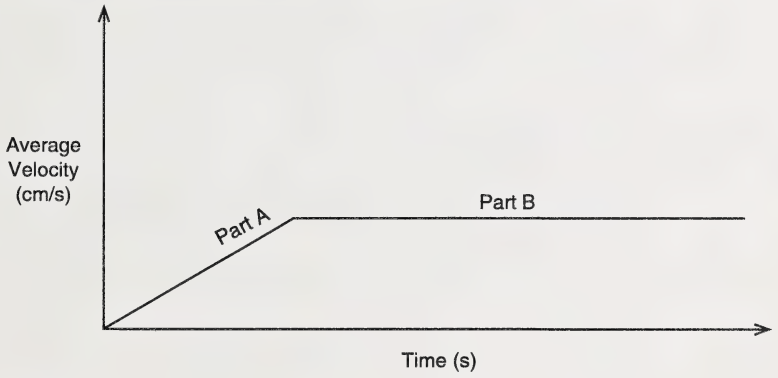
$= -10.0 \text{ m/s}^2$, east **(3 marks)**

b. The negative means that the object is decelerating in a positive direction or the same direction as the original motion. **(1 mark)**

7. a. The object is accelerating in a positive direction. **(1 mark)**

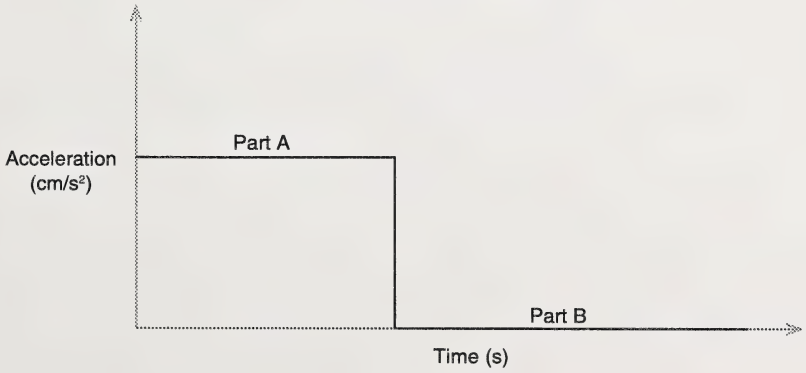
b. The object is travelling with uniform motion in a positive direction. **(1 mark)**

c.



(2 marks)

d.



(2 marks)

8. No, if the object is decelerating, the deceleration is in an opposite direction to the velocity. **(1 mark)**

Section 3: Newton's Laws of Motion

Key Concepts

- causes of motion
- development and application of Newton's First Law of Motion
- development of Newton's Second Law of Motion
- applying Newton's Second Law of Motion
- development and application of Newton's Third Law of Motion

Section 3: Assignment Answer Key (40 marks)

1. a. Newton's First Law is evident in two situations: while on the pad (an object at rest will remain at rest) and in space, where forces due to gravity are negligible (an object in motion will remain at uniform motion in a straight line). This law aided the voyage in that once the spacecraft is put into a pathway to take it to a particular place, no further energy is required unless it is required that the path be changed. **(2 marks)**

   b. Newton's Second Law is evident whenever the rockets are fired creating a force necessary to accelerate the spacecraft. This allows the rocket to launch the *Apollo* spacecraft. **(2 marks)**

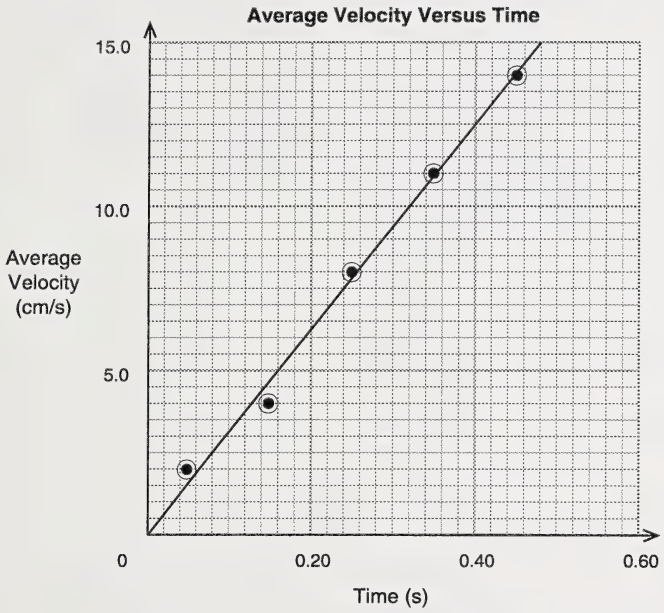
   c. Newton's Third Law is also evident whenever the rockets are fired. The action force is the spacecraft forcing gases in the rockets out. The reaction force is the gases pushing the spacecraft in the opposite direction. This law allows the spacecraft to maneouver in space. **(2 marks)**

2. a.

AVERAGE VELOCITIES DURING A TIME INTERVAL		
Time (s)	**Displacement from Previous Dot (cm)**	**Average Velocity During Each Interval (cm/s)**
0.0		
	0.2	2
0.1		
	0.4	4
0.2		
	0.8	8
0.3		
	1.1	11
0.4		
	1.4	14
0.5		

(2 marks)

b. Your graph should be similar to the following:



(4 marks)

c. $\text{acceleration} = \text{slope} = \dfrac{\text{rise}}{\text{run}}$

$= \dfrac{12.5\ \text{cm/s}}{0.40\ \text{s}}$

$= 31\ \text{cm/s}^2$ (2 significant digits) **(2 marks)**

d. $\vec{F} = m \times \vec{a}$

$= 0.400\ \text{kg} \times 0.31\ \text{m/s}^2$

$= 0.12\ \text{N}$, toward the centre of the Earth (2 significant digits) **(3 marks)**

Note: The units in newtons are $\text{kg} \bullet \text{m/s}^2$; thus, mass must be in kg and acceleration in m/s^2.

3. Method 1

$F = m \times g$

$= 5.00\ \text{kg} \times 9.81\ \text{m/s}^2$

$= 49.1\ \text{N}$ (3 significant digits) **(2 marks)**

Method 2

$F_g = \dfrac{Gm_1 m_2}{\Delta r^2}$

$= \dfrac{6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2 \times 5.00\ \text{kg} \times 5.97 \times 10^{24}\ \text{kg}}{(6.40 \times 10^6\ \text{m})^2}$

$= 48.6\ \text{N}$ (3 significant digits) **(2 marks)**

4. a. Mass is constant. It will be 5.00 kg. **(1 mark)**

b. $W = m \times g$

$= 5.00 \text{ kg} \times 1.64 \text{ m/s}^2$

$= 8.20 \text{ N}$

(2 marks)

5. The action force is the pressure of the cannon walls forcing the exploding gases and the cannonball out. **(1 mark)**

The reaction force is the exploding gases pushing the cannon backward creating a recoil. **(1 mark)**

6. a. $\vec{a} = \dfrac{\vec{F}}{m}$

$= \dfrac{15.0 \text{ N}}{6.00 \text{ kg}}$

$= 2.50 \text{ m/s}^2$, in the direction of the force **(3 marks)**

b. Calculate the force necessary to accelerate Block C.

$\vec{F} = m \times \vec{a}$

$= 3.00 \text{ kg} \times 2.50 \text{ m/s}^2$

$= 7.50 \text{ N}$, in the direction of the original force **(2 marks)**

The reaction force of Block C must be 7.50 N in the opposite direction of the original force. **(1 mark)**

7. a. Your head snaps back. This situation illustrates Newton's First Law of Motion. Your head was in a state of rest when the car was hit and tends to stay in a state of rest while the seat moves the remainder of your body forward. **(3 marks)**

b. The purpose of the headrest is to push your head forward so it moves with the rest of your body before a neck injury can occur. **(1 mark)**

8. Answers will vary but could include walking, driving, keeping your hands warm, running, and so on. **(2 marks)**

9. g is the acceleration due to the force of gravity and is dependent on the mass of the body providing the gravitational force. G is the universal gravitational constant used in the formula for the attraction between any two masses. **(2 marks)**

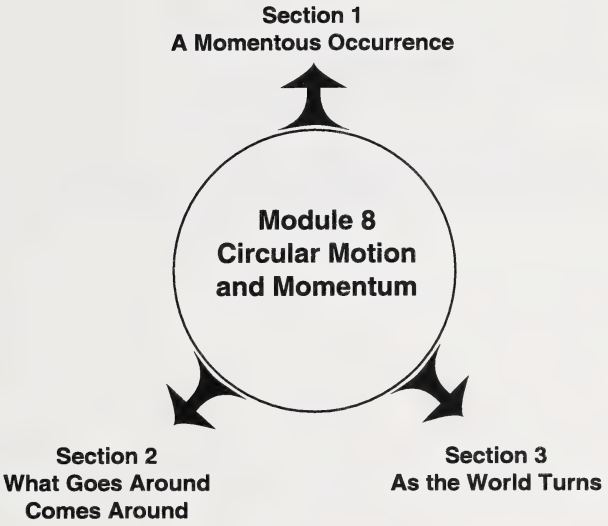
Module 8: Circular Motion and Momentum

Overview

This module continues the students' study of how and why objects move. Section 1 introduces students to the concept of momentum with emphasis on conservation of momentum and how collision problems can be solved using the Law of Conservation of Momentum. Students can perform a laboratory investigation which verifies the Law of Conservation of Momentum.

In Section 2, students are introduced to the concept of circular motion and what forces are involved in circular motion. Students can perform a simple laboratory investigation which confirms the formula for centripetal force and reinforces the concepts of circular motion.

Section 3 qualitatively applies the concepts of circular motion to how the planets move and how satellites orbit the Earth. Newton's Universal Law of Gravitation is studied. A number of ideas on space exploration including the concept of space stations are discussed.



Evaluation

The evaluation of this module will be based on three assignments:

Section 1 Assignment	**40 marks**
Section 2 Assignment	**35 marks**
Section 3 Assignment	**25 marks**
Total	**100 marks**

Materials and Equipment

Section 1: Activity 2

Investigation: Conservation of Momentum

Part A

- 2 dynamics carts (one with spring-loaded plunger)
- ticker tape timer with ticker tape
- laboratory mass set
- triple beam balance or electronic balance
- ruler or metre stick
- 2 pencils
- strong elastic bands
- masking tape

Part B

- ticker tape results (given at the end of the Appendix)
- transparent, adhesive tape
- centimetre ruler (given at the end of the Appendix)
- scissors

Section 2: Activity 1

Investigation: The Factors of Circular Motion

- stout cord (approximately 1.00 m in length)
- plastic container with a handle (e.g., plastic milk jug)

Section 2: Activity 2

Investigation: Confirming the Centripetal Force Formula

Part A

- hollow glass tube, 20 cm long, fire-polished, and wrapped in masking tape to reinforce the glass
- 1.5 m of nylon cord, small enough to pass through the glass tube (e.g., 10 kg fishing line)
- two hole stopper
- laboratory mass weight set
- stopwatch
- masking tape
- triple beam balance or electronic balance
- metre stick

Part B

- Data results provided in the Procedure section
- pen or pencil
- paper
- calculator

Additional Resources

Zitzewitz, Davids, and Neff. *Merrill Physics: Principles and Problems*. Maxwell MacMillan. Canada: 1992.

Giancoli, Douglas C., *Physics*, Prentice Hall Inc. Englewood Cliffs, New Jersey: 1991.

Optional Videos

Section 3: Extra Help

Apple and the Moon, *Mechanical Universe* series, ACCESS Network.

Section 1: A Momentous Occurence

Key Concepts

- Impulse is a force applied over a period of time.
- Momentum is equal to mass times velocity.
- An impulse is required to produce a change in momentum.
- Momentum is conserved in an interaction.

Section 1: Assignment Answer Key (40 marks)

1. a. $\vec{I} = \vec{F}\Delta t$

$$= \frac{1}{2}(800\text{ N})(5.00\times10^{-3}\text{ s}) + \frac{1}{2}(300\text{ N})(5.00\times10^{-3}\text{ s}) + (500\text{ N})(8.00\times10^{-3}\text{ s}) + \frac{1}{2}(500\text{ N})(5.00\times10^{-3}\text{ s})$$

$$= 2.00\text{ N}\bullet\text{s} + 0.750\text{ N}\bullet\text{s} + 4.00\text{ N}\bullet\text{s} + 1.25\text{ N}\bullet\text{s}$$

$$= 8.00\text{ N}\bullet\text{s}$$

The total impulse is $8.00\text{ N}\bullet\text{s}$ in the direction of the force. **(3 marks)**

b. $\vec{F}\Delta t = m\Delta\vec{v}$

$$\Delta\vec{v} = \frac{\vec{F}\Delta t}{m}$$
$$= \frac{8.00\ \text{N}\bullet\text{s}}{4.00\ \text{kg}}$$
$$= 2.00\ \text{m/s}$$

The change in velocity is 2.00 m/s relative to the force. **(3 marks)**

2. $\vec{F}\Delta t = m\Delta\vec{v}$

$$\vec{F} = \frac{m\Delta\vec{v}}{\Delta t}$$
$$= \frac{(0.035\ \text{kg})(3.71\ \text{m/s})}{2.00\times10^{-2}\ \text{s}}$$
$$= 6.49\ \text{N}\ \text{(3 significant digits)}$$

The average force exerted on the egg is about 6.49 N in the opposite direction to which the egg was moving. **(3 marks)**

3. $\vec{F}\Delta t = m\Delta\vec{v}$

$$\Delta\vec{v} = 30.0-(-35.0)$$
$$= 65.0\ \text{m/s}$$
$$\vec{F} = \frac{(0.265\ \text{kg})(65.0\ \text{m/s})}{(4.50\times10^{-3}\ \text{s})}$$
$$= 3.83\times10^{3}\ \text{N}\ \text{(3 significant digits)}$$

The average force experienced by the ball is about 3.83×10^{3} N in the direction of the final velocity of the ball. **(4 marks)**

4. Impulse is force times change in time. In a collision, the impulse stays the same. Thus, if change in time is increased in the process of crushing, then the force on your head is correspondingly decreased. If the helmet were made of a hard plastic, the impulse would be transferred in less time and the force would be greater. (Cost is probably another factor. A reasonably safe but inexpensive helmet can be made from Styrofoam.) **(4 marks)**

5. Assume east is positive.

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1+m_2)\vec{v}'$$
$$(3.50\times10^{3}\ \text{kg}\times20.0\ \text{km/h})+(1.20\times10^{3}\ \text{kg}\times-60.0\ \text{km/h}) = (3.50\times10^{3}\ \text{kg}+1.20\times10^{3}\ \text{kg})\vec{v}'$$
$$7.00\times10^{4}\ \text{kg}\bullet\text{km/h}+(-7.20\times10^{4}\ \text{kg}\bullet\text{km/h}) = (4.70\times10^{3}\ \text{kg})\vec{v}'$$
$$\frac{-2.00\times10^{3}\ \text{kg}\bullet\text{km/h}}{4.70\times10^{3}\ \text{kg}} = \vec{v}'$$
$$\vec{v}' = -4.26\times10^{-1}\ \text{km/h}$$

The wreckage is travelling approximately 4.26×10^{-1} km/h, west. **(4 marks)**

6.
$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1{}' + m_2\vec{v}_2{}'$$
$$(1.67\times10^{-27}\text{ kg})(3.50\times10^{2}\text{ m/s}) + (2.01\times10^{-26}\text{ kg})(0\text{ m/s}) = (1.67\times10^{-27}\text{ kg})(-3.20\times10^{2}\text{ m/s}) + (2.01\times10^{-26}\text{ kg})\vec{v}_2{}'$$
$$5.845\times10^{-25}\text{ kg}\bullet\text{m/s} = -5.344\times10^{-25}\text{ kg}\bullet\text{m/s} + (2.01\times10^{-26}\text{ kg})\vec{v}_2{}'$$
$$\frac{5.845\times10^{-25}\text{ kg}\bullet\text{m/s} + 5.344\times10^{-25}\text{ kg}\bullet\text{m/s}}{2.01\times10^{-26}\text{ kg}} = \vec{v}_2{}'$$
$$\vec{v}_2{}' = \frac{1.1189\times10^{-24}\text{ kg}\bullet\text{m/s}}{2.01\times10^{-26}\text{ kg}}$$
$$= 55.7\text{ m/s (3 significant digits)}$$

The velocity of the carbon nucleus is about 55.7 m/s in a positive *x*-direction. **(4 marks)**

7.
$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}_1{}'$$
$$(1500\text{ kg})(20.0\text{ km/h}) + 0 = (1500\text{ kg} + m_2)(7.50\text{ km/h})$$
$$3.00\times10^{4}\text{ kg}\bullet\text{km/h} = (1500\text{ kg} + m_2)(7.50\text{ km/h})$$
$$1500\text{ kg} + m_2 = \frac{3.00\times10^{4}\text{ kg}\bullet\text{km/h}}{7.50\text{ km/h}}$$
$$m_2 = 4.00\times10^{3}\text{ kg} - 1500\text{ kg}$$
$$= 2.50\times10^{3}\text{ kg}$$

The stationary vehicle has a mass of 2.50×10^{3} kg. **(4 marks)**

8. Momentum before the shell is fired is equal to momentum after the shell is fired.

Let the final velocity of the tank be $\vec{v}_1{}'$.

$$(m_1 + m_2)\vec{v} = m_1\vec{v}_1{}' + m_2\vec{v}_2{}'$$
$$(3.50\times10^{4}\text{ kg} + 10.0\text{ kg})\times5.00\text{ km/h} = (3.50\times10^{4}\text{ kg})\vec{v}_1{}' + (10.0\text{ kg}\times1.60\times10^{3}\text{ km/h})$$
$$1.7505\times10^{5}\text{ kg}\bullet\text{km/h} = (3.50\times10^{4}\text{ kg})\vec{v}_1{}' + 1.60\times10^{4}\text{ kg}\bullet\text{km/h}$$
$$\frac{1.5905\times10^{5}\text{ kg}\bullet\text{km/h}}{3.50\times10^{4}\text{ kg}} = \vec{v}_1{}'$$
$$\vec{v}_1{}' = 4.54\text{ km/h (3 significant digits)}$$

The velocity of the tank immediately after the shell is fired is about 4.54 km/h, north. **(4 marks)**

9. The angle of 46° is close enough to 45° that it can be assumed the momenta of both cars were equal. Since the mass of Car B is $\frac{2.50\times10^{3}\text{ kg}}{1.50\times10^{3}\text{ kg}} \doteq 1.67$ times larger than the mass of Car A, then Car A must have been going about 1.67 times faster (since $m_A v_A = m_B v_B$ before the collision). If Car B went 60 km/h, then Car A must have gone $60\text{ km/h}\times1.67 \doteq 100\text{ km/h}$. Driver B is telling the truth. **(4 marks)**

10. Impulse is force times change in time. For a given force if the bat or golf club can be in contact with the ball for a longer period of time (change in time is greater), then the impulse will be greater. The greater the impulse imparted to the ball, the further it will travel.
(3 marks)

Section 2: What Goes Around Comes Around

Key Concepts

- Circular motion requires a constant force called centripetal force.
- Centripetal force is always towards the centre of the circle.
- Centripetal force is determined by mass, velocity, and radius of the path of motion.
- Centripetal force can also be found in terms of mass, radius of path of motion, and time for one revolution.
- Centrifugal force is an imaginary force used to explain what is observed or felt during circular motion.

Section 2: Assignment Answer Key (35 marks)

1. a. As the wet clothes are spun around, the wet clothes are forced against the side of the tub. The water goes through the holes in the side of the tub but the clothes do not. **(2 marks)**

   b. The force is considered a fictitious force because it is really the effect of a tendency of a mass to continue in a straight line. **(1 mark)**

2. When you go around, your tendency to go in a straight line makes you feel as if you are pushed to one side of the seat. The roadway is banked so that gravity pulls you in the opposite direction. At the appropriate speed and appropriate banking, there will be no net force. **(3 marks)**

3. $$F = \frac{mv^2}{r}$$

   $$v^2 = \frac{Fr}{m}$$

   $$v^2 = \frac{(220\ \text{N})(100\ \text{m})}{70.0\ \text{kg}}$$

   $$v = \sqrt{314.29}$$

   $$= 17.7\ \text{m/s}\ \text{(3 significant digits)}$$

   The car would have to travel about 17.7 m/s. **(4 marks)**

4. a. Forty revolutions in one minute is forty revolutions in sixty seconds.

   $$T(\text{period}) = \frac{t(\text{time})}{\text{number of revolutions}}$$

   $$= \frac{60.0\ \text{s}}{40.0\ \text{rev}}$$

   $$= 1.50\ \text{s/rev}$$ **(2 marks)**

   b. $$a = \frac{4\pi^2 r}{T^2}$$

   $$= \frac{4\pi^2(0.600\ \text{m})}{(1.50\ \text{s})^2}$$

   $$= 10.5\ \text{m/s}^2\ \text{(3 significant digits)}$$

   The fly experiences a centrifical acceleration of $10.5\ \text{m/s}^2$. **(3 marks)**

5. a.

Hanging Mass (kg)	Force (N)	Time for Twenty Revolutions (s)	Time for One Revolution (s)	Instantaneous Speed of Unknown Mass (m/s)	Speed^2 (m^2/s^2)
0.200	1.96	43.9	2.20	2.29	5.24
0.400	3.92	31.1	1.56	3.23	10.4
0.600	5.89	25.4	1.27	3.96	15.7
0.800	7.85	22.0	1.10	4.57	20.9
1.00	9.81	19.6	0.980	5.13	26.3

The following calculations are for the first row of the chart. The unrounded values from the previous steps have been kept in the calculator where required.

Calculate the force in newtons.

$$F = mg$$
$$= 0.200\ \text{kg} \times 9.81\ \text{m/s}^2$$
$$= 1.96\ \text{N}\ \text{(3 significant digits)}$$

Calculate the time for one revolution.

$$t = \frac{43.9\ \text{s}}{20}$$
$$= 2.195$$
$$= 2.20\ \text{s}\ \text{(3 significant digits)}$$

Calculate the instantaneous speed of the unknown mass.

$$v = \frac{d}{t}$$
$$= \frac{2\pi r}{t}$$
$$= \frac{2\pi(0.800\ \text{m})}{2.195}$$
$$= 2.2899$$
$$= 2.29\ \text{(3 significant digits)}$$

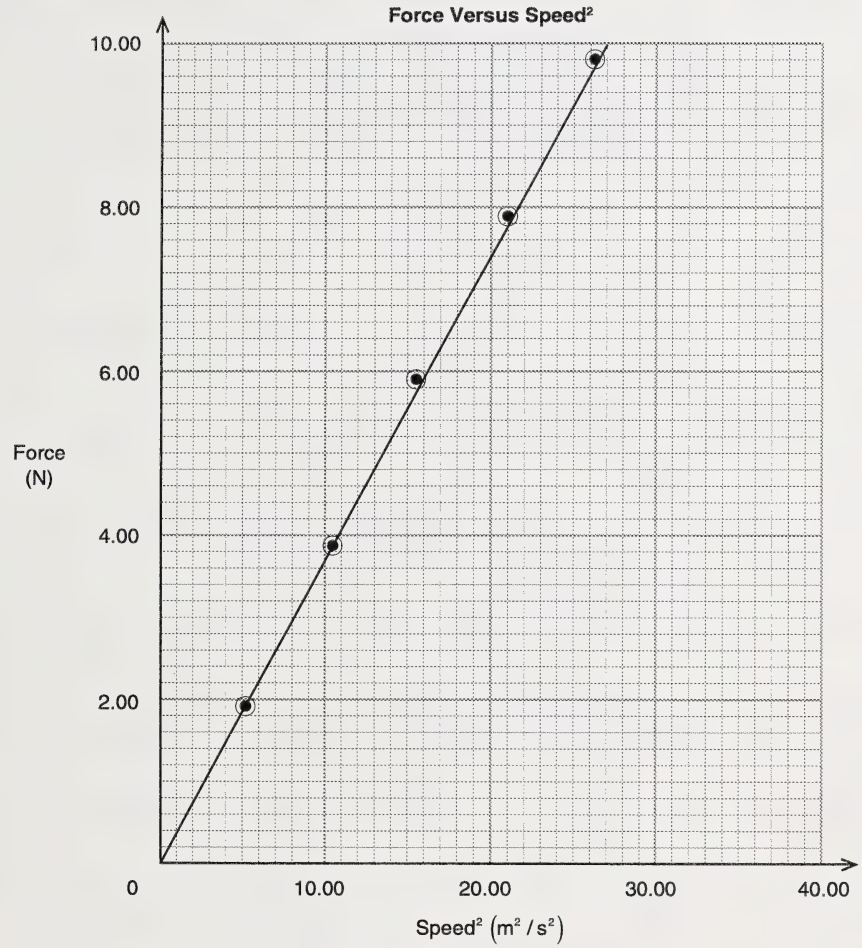
Calculate the square of the speed.

$$v^2 = (2.2899)^2$$
$$= 5.24\ \text{(3 significant digits)}$$

Note: d is equal to circumference, which is given by the formula $2\pi r$.

(5 marks)

b. The force provided by the hanging mass is equivalent to the centripetal force. The student's graph should be similar to the following graph. **(3 marks)**



c. Calculate the force for a hanging mass of 0.300 kg.

$$F = mg$$
$$= 0.500\ \text{kg} \times 9.81\ \text{m/s}^2$$
$$= 4.905$$
$$= 4.91\ \text{N}\ \ (3\ \text{significant digits})$$

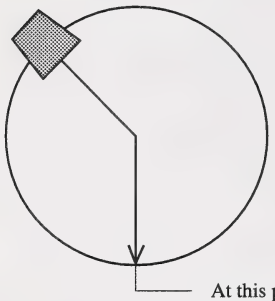
From the graph, the speed squared for a force of 4.91 N is approximately 13.5 m^2/s^2.

Calculate the value of the swinging mass using the following formula.

$$F = \frac{mv^2}{r}$$
$$m = \frac{Fr}{v^2}$$
$$= \frac{(4.905\ \text{N})(0.800\ \text{m})}{13.5\ \text{m}^2/\text{s}^2}$$
$$= 0.291\ \text{kg}\ \ (3\ \text{significant digits})$$

The mass of the swinging object is calculated to be about 0.291 kg. **(3 marks)**

6.



At this point, centripetal force and gravity act on the string. **(2 marks)**

7. The bath scale will read the greatest value when the radius of the loop travelled by the airplane is the smallest (when the radius of the loop is 500 m). **(2 marks)**

8. a. Gravity tends to pull your feet down. A rotating cylinder will force your feet against the side thereby forcing you to use your muscles. **(2 marks)**

b. $$a = \frac{v^2}{r}$$
$$v^2 = ar$$
$$v = \sqrt{ar}$$
$$= \sqrt{(9.81\ \text{m/s}^2)(1000\ \text{m})}$$
$$= 99.0\ \text{m/s}\ \ (3\ \text{significant digits})$$

Change to km/h.

$$\frac{99.0\ \text{m/s} \times 60\ \text{s/min} \times 60\ \text{min/h}}{1000\ \text{m/km}} = 356\ \text{km/h}\ \ (3\ \text{significant digits})$$

The space station must rotate at approximately 356 km/h. **(3 marks)**

Section 3: As the World Turns

Key Concepts

- A number of astronomers influenced modern concepts of planetary and satellite motion.
- Newton's Universal Law of Gravitation relates the force of attraction of any two masses.
- Gravitational force provides the centripetal force for satellite and celestrial body motion.
- The velocity of an orbiting body is affected by the mass of the body which it orbits as well as the orbital radius.
- Geostationary satellites above the Earth have only one orbital radius and velocity.
- Space stations provide a number of challenges for future scientists and physicists.

Section 3: Assignment Answer Key (25 marks)

1. It allowed for the methodical locating of stars and planets for use in navigation as well as initiating planting and harvesting dates. **(2 marks)**

2. Kepler's model had the planets orbiting the sun in non-circular (elliptical) paths. Kepler used Tycho Brahe's extremely accurate observational data to match planetary orbits with his theoretical calculations. **(3 marks)**

3. No, such a satellite cannot be put at any distance above the Earth. A geostationary satellite must orbit a specific orbital speed to keep it stationary above any point above the Earth. Since orbital velocity is dependent on the radius of orbit, only one radius will give the satellite a specific orbital speed. **(3 marks)**

4. Astronomers could predict the existence of Neptune before it was seen by its effect on the orbits of other known planets. **(2 marks)**

5. The astronaut feels weightless because the attraction by the mass of the Earth is balanced by the centrifugal force of the orbit. **(2 marks)**

6. The orbital velocity of the satellite halfway between the Earth and the moon would be less since the velocity of an object decreases as the orbital radius increases. **(2 marks)**

7. The bones, especially in the legs, would have to be thicker to support the body under the effect of a greater gravitational pull. The muscles, including those of the heart, would have to be more massive and stronger so that the human could move under the greatly increased effect of gravity. **(3 marks)**

8. According to the formula, the mass of the orbiting body has no effect on its velocity. Therefore, the two particles will continue to travel at the same velocity and neither one will overtake the other. **(2 marks)**

9. Three reasons which could justify the building of a space station are as follows:

    - Orbiting space stations provide excellent sites for research into areas of pure science difficult to manage on Earth; for example, astronomy, effect of a vacuum on chemical production, crystal formation, and so on.

    - They provide sites for observing the Earth in regard to meteorology, vegetation, and so on.

    - They provide stations for construction and launch of interplanetary and interstellar craft.

    (3 marks)

10. According to Kepler's Second Law, the time for the planet to go from A to B is the same as the time for it to go from C to D. Since the distance from A to B is greater than the distance from C to D, the speed of the planet must be greater at A than at C if it is to travel the two distances in the same amount of time. **(3 marks)**

Final Test

Included here is the answer key to the final test and the student's copy of the final test which is designed for photocopying and possible faxing.

Note:

The answer key and student's copy of this final test should be kept secure by the teacher. Students should not have access to this test until it is assigned in a supervised situation. The answers should be stored securely and retained by the teacher at all times.

Calculators are recommended when writing this test. A formula sheet, a periodic table, and other necessary information are included at the end of this test.

SCIENCE 20

FINAL TEST ANSWER KEY

Part A: Multiple Choice (55 marks)

1. C	12. C	23. B	34. C	45. D
2. B	13. C	24. A	35. B	46. A
3. C	14. D	25. D	36. C	47. D
4. D	15. A	26. B	37. D	48. C
5. B	16. D	27. D	38. C	49. A
6. B	17. A	28. A	39. A	50. A
7. B	18. D	29. B	40. C	51. C
8. B	19. C	30. C	41. A	52. A
9. A	20. A	31. A	42. A	53. D
10. B	21. B	32. A	43. B	54. C
11. A	22. A	33. B	44. A	55. B

Part B: Written Response (35 marks)

1. Answers may vary. Any other response similar to the following is acceptable.

   a. Society knows that burning fossil fuels and deforestation liberate CO_2. CO_2 levels are increasing in correspondence with these practices. CO_2 is a greenhouse gas; therefore, a build up of this gas in the atmosphere affects global temperatures. Since global warming has potentially devastating consequences, society should do whatever it takes to prevent it from happening. **(2 marks)**

   b. Before there is conclusive proof that global warming is happening, it might be too late to stop the devastation. Society's "fixes" may have unforseen consequences harmful to the ecosystem. Fixing the problem later may cost much more. Reducing the greenhouse gases that lead to global warming is good for the environment in many other ways; therefore, we should do it regardless of the global warming issue. **(2 marks)**

2. Answers may vary. The following are suggested responses. Give one mark for each appropriate response.

   - economical benefits:
     - aid in discovering sources of energy (e.g., fossil fuels like coal and oil)
     - aid in locating other resources (e.g., amolite (Alberta fossil gemstone), slate, limestone for cement, and so on)
     - tourism – Royal Tyrrell Museum of Palaeontology in Drumheller, Alberta, and travelling exhibits.
   - social benefits:
     - closer ties with other countries, like China, through sharing of knowledge and expertise in a variety of disciplines
   - environmental benefits:
     - Past changes in climate, vegetation, and so on may be found to be cyclical and could therefore be used to help forecast future changes.

   (3 marks)

3. a. $\frac{12 \times 100}{80} = 15\%$ **(1 mark)**

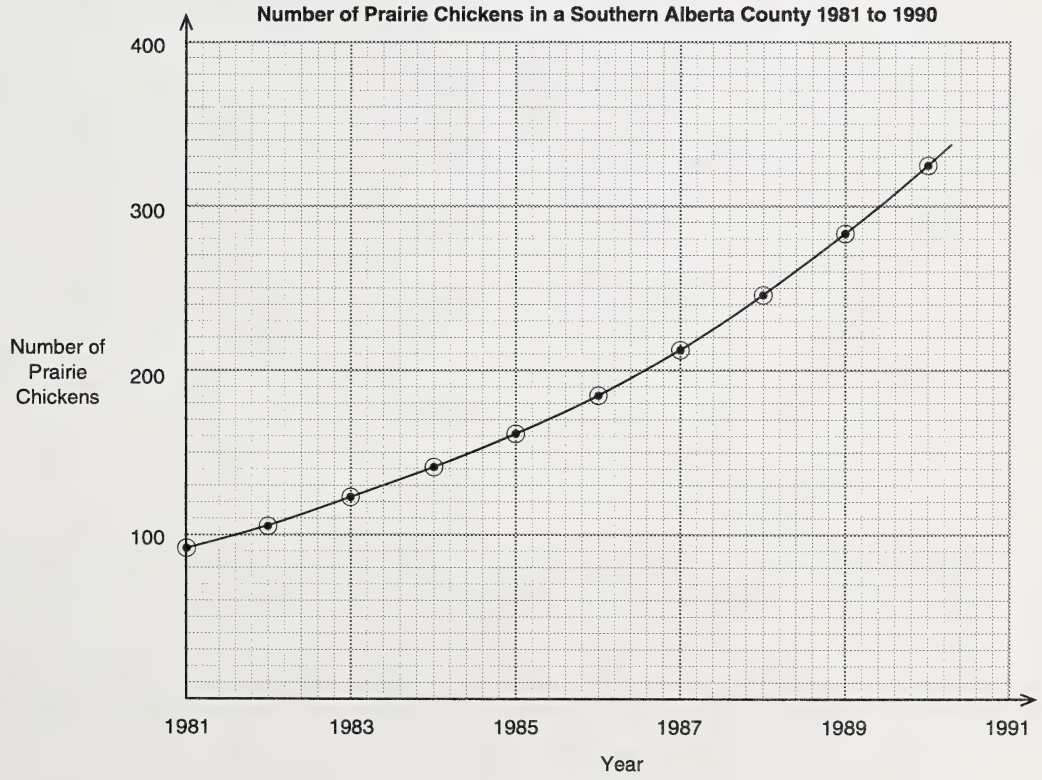
b.

Year	Number of Prairie Chickens	Year	Number of Prairie Chickens
1981	92	1986	185
1982	106	1987	213
1983	122	1988	245
1984	140	1989	282
1985	161	1990	324

(1 mark)

Calculations for the first two are as follows:

$$\frac{115\% \times 92}{100} = 106 \qquad \frac{115\% \times 106}{100} = 122$$



(2 marks)

c. The population should level off. **(1 mark)**

d.
- Predators will catch prairie chickens more easily.
- A food shortage will slow down growth.
- A lack of nesting sites will limit reproduction.
- Migration may slow population growth.

(2 marks)

4. a. Individuals with blood type O are the most fit because they have the best chance of surviving the virus and producing offspring. **(1 mark)**

b. The virus would provide selection pressure which would cause the frequency of blood type O to increase and all the others to decrease. If this situation remained for a long time, the only blood type found in the human population would be type O. **(1 mark)**

c. The selection pressure is the pathogenic virus. **(1 mark)**

5. a. $NH_{3(g)} + HNO_{3(aq)} \rightarrow NH_4NO_{3(s)}$ **(1 mark)**

b. $$n_{HNO_3} = \frac{800\ \text{L} \times 15.4\ \text{mol/L}}{1000\ \text{mol/kmol}}$$
$$= 12.3\ \text{kmol}\ \text{(3 significant digits)}\ \textbf{(2 marks)}$$

c. $$n_{NH_3} = 12.3\ \text{kmol} \times \frac{1\ \text{kmol of } NH_{3(g)}}{1\ \text{kmol of } HNO_{3(aq)}}$$
$$= 12.3\ \text{kmol}\ \text{(3 significant digits)}\ \textbf{(2 marks)}$$

d. $$m_{NH_3} = 12.3\ \text{kmol} \times 17.04\ \text{g/mol}$$
$$= 210\ \text{kg}\ \text{(3 significant digits)}\ \textbf{(2 marks)}$$
(Note : 17.04 g/mol = 17.04 kg/kmol)

6. Allow one mark for each explanation and one mark for each example. Examples will vary.

In a substitution reaction, an atom of some substance will substitute for a hydrogen atom in the organic compound. The number of atoms in the compound stays the same. Look at the following example.

$$C_3H_{8(g)} + Br_{2(g)} \xrightarrow{\text{UV light}} C_3H_7Br_{(l)} + HBr_{(g)}$$

In an addition reaction, the number of atoms in the organic compound increase. Look at the following examples.

$$CH_2 = CH_{2(g)} + H_2O_{(l)} \rightarrow CH_3 - CH_2OH_{(l)}$$

$$CH_2 = CH - CH_2 - CH_{3(g)} + H_{2(g)} \xrightarrow{Ni} CH_3 - CH_2 - CH_2 - CH_{3(g)}$$

$$H - C \equiv C - H + Br - Br \rightarrow H - \overset{Br}{\underset{|}{C}} = \overset{Br}{\underset{|}{C}} - H$$

7. The water heats up, creating steam. The steam builds up in the flask and forces out the small opening. This steam pushes against the air particles (action force), and the air particles push back against the steam (reaction force). The reaction force of the air moves the vehicle forward. This may work for a light toy vehicle; but for a vehicle capable of carrying human passengers, there is not enough reaction force. **(3 marks)**

8. When you bend your knees, time for landing is made larger. Since the total impulse depends on the height of the bench, the total impulse is the same whether you bend your knees or not. If time is larger, then the force must be smaller. Therefore, with the smaller force, the resulting pain to your knees and upper body is less when landing on the ground. **(3 marks)**

SCIENCE 20

FINAL TEST

GENERAL INSTRUCTIONS

YOU HAVE **TWO** HOURS TO COMPLETE THIS TEST. Work through the entire test answering the questions you are sure you know. You will then be able to concentrate on the questions of which you are not quite sure.

TOTAL MARKS: 90

PART A: Multiple Choice 55 marks

PART B: Written Response 35 marks

Note: Calculators are recommended when writing this test. A formula sheet, a periodic table, and other necessary information are included at the end of this test.

Value

PART A: MULTIPLE CHOICE

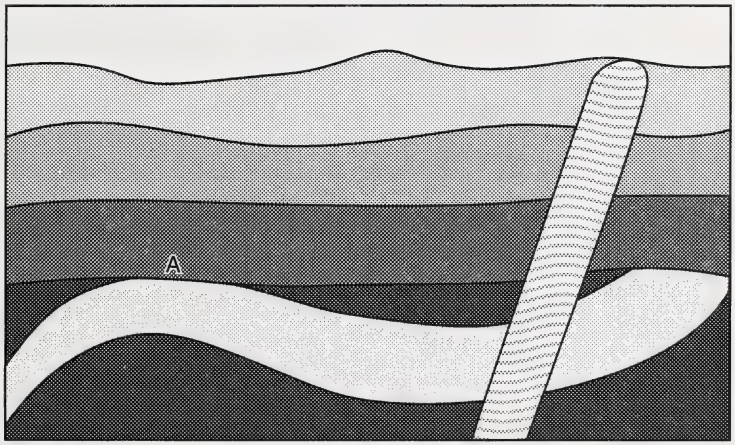
55

All multiple-choice questions must be answered on the Part A Response Page included in your test.

Read each question carefully and decide which of the choices BEST completes the statement or answers the question. Locate the question number on the Response Page and fill in the space that corresponds to your choice.

Use the following diagram to answer question 1.

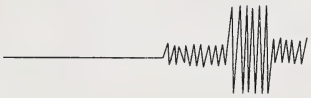
Sedimentary Rock Layers

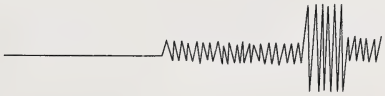


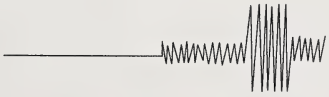
1. Which of the following best describes the disruption at A?

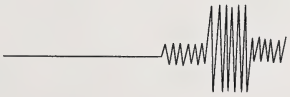
   A. a fault
   B. an intrusion
   C. an unconformity
   D. tilted sedimentary layers

2. The following are seismograph records from four different locations during an earthquake. Which record is taken from the seismic station farthest from the epicentre of the earthquake?

   A. 

   B. 

   C. 

   D. 

3. The plastic region of the Earth's mantle in which convection currents are believed to exist is the

   A. moho
   B. lithosphere
   C. asthenosphere
   D. paleosphere

4. The current theory explaining the formation of mountains on the west coast of Canada suggests that these mountains were formed primarily by

   A. mass erosion caused by the meltwater from the receding glaciers of the last ice age
   B. continental crustal uplift which occurred as glacial ice melted at the end of the last ice age
   C. little understood surges of rising magma creating pressure and causing a buckling of the Earth's crust
   D. a buckling of the Earth's crust along the converging boundary between the North American plate and the Pacific plate

5. Glaciers move as a result of

   A. melting
   B. gravity
   C. the climate becoming warmer
   D. alternate thawing and refreezing

Use the following information to answer question 6.

An index fossil is one that proves useful in the process of chronological matching and ordering of rock sequences. To be considered an index fossil, a fossil should be representative of an organism which fulfills certain criteria.

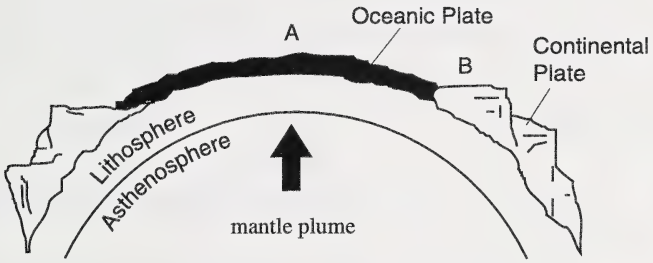
6. An index fossil would most likely arise from an organism that is

   A. slow to evolve and relatively scarce
   B. widespread geographically and evolving rapidly
   C. confined to specific regions and evolving slowly
   D. widespread geographically and of highly variant characteristics

7. Uranium (238) decays to lead (206). How many grams of lead (206) would be present in a 200 g sample of uranium (238) after three half-lives?

   A. 67 g
   B. 175 g
   C. 200 g
   D. 75 g

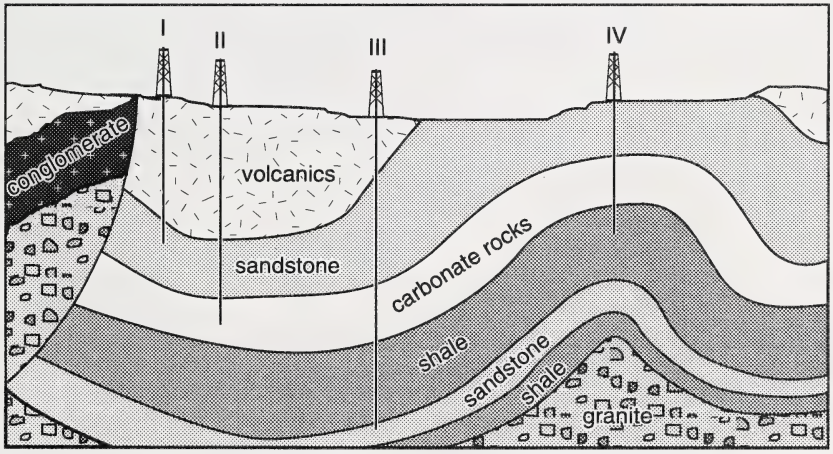
Use the following information to answer question 8.



8. At position B, the oceanic plate would be

   A. stationary
   B. subducting
   C. moving towards A
   D. welded to the continental plate

Use the following information to answer questions 9 and 10.



You are an oil exploration geologist with an oil company that has limited funds and can only develop one site.

9. In which site would you advise the company to invest?

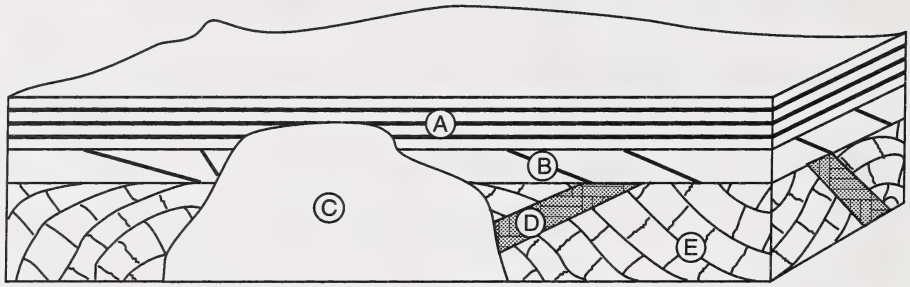
   A. I
   B. II
   C. III
   D. IV

10. If the climate for oil investment improves, which of the remaining sites would you recommend for development?

A. I
B. II
C. III
D. IV

Use the following information to answer question 11.

An excavation of a section of land reveals the following geological cross section.



Note: Rocks A, B, and E are sedimentary; and rocks C and D are igneous.

11. Which of the following sequences represents the ordering of rocks from oldest to youngest?

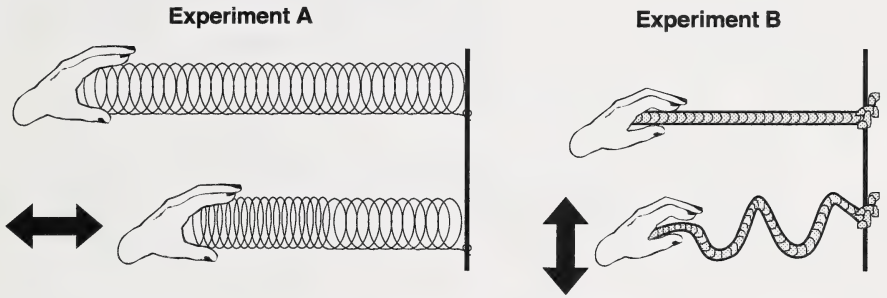
A. E, D, B, A, C
B. A, C, B, D, E
C. A, B, C, D, E
D. E, D, C, B, A

12. Pyramids showing the relationships between organisms in an ecosystem do not show their

A. biomass
B. numbers
C. diversity
D. energy

Use the following information to answer question 13.

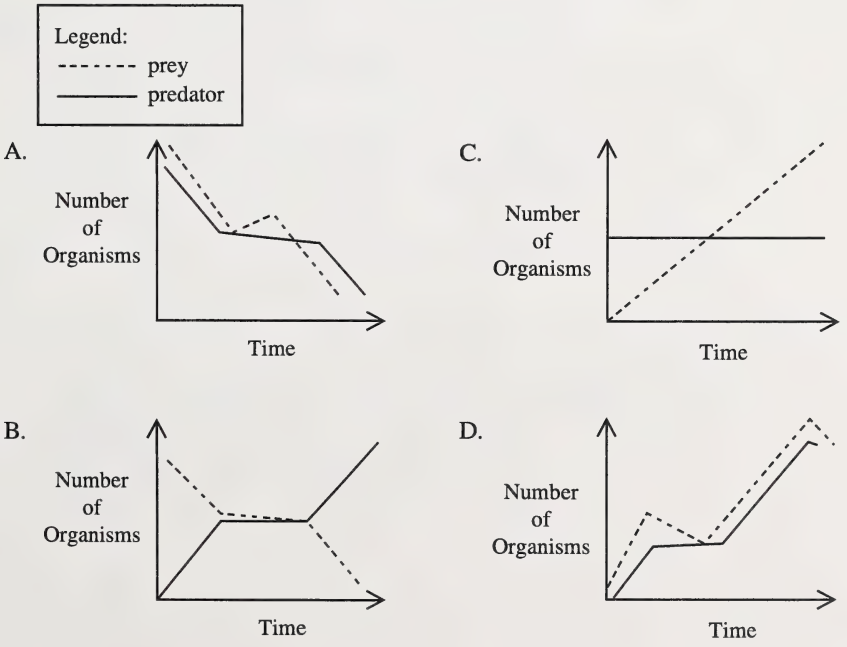
A student performs Experiment A and Experiment B to illustrate the propagation of seismic waves.



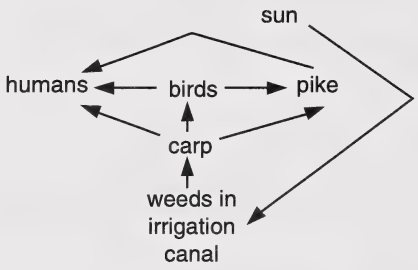
13. The type of waves demonstrated by these experiments were

A. longitudinal waves in Experiment A and surface waves in Experiment B
B. elastic waves in Experiment A and transverse waves in Experiment B
C. longitudinal waves in Experiment A and transverse waves in Experiment B
D. primary waves in Experiment A and surface waves in experiment B

14. Which graph supports the hypothesis that the population of a single predator increases as the population of its prey increases?

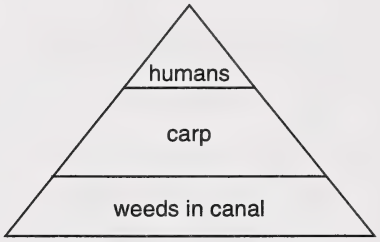


Use the following information to answer question 15.

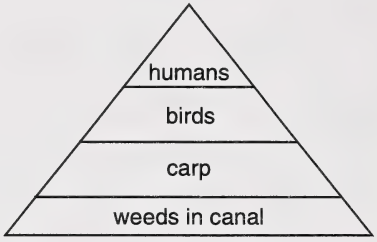


15. Which biomass pyramid, derived from the food web, shows humans feeding at the lowest trophic level?

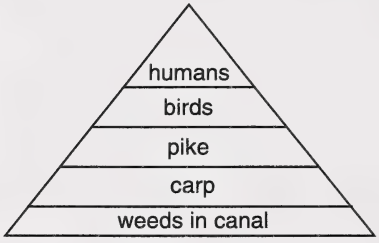
A.



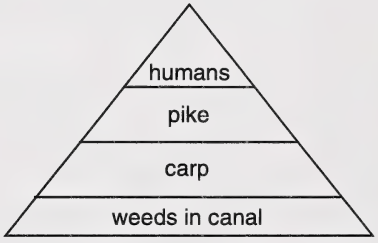
C.



B.



D.



16. Cows and whitetail deer are seen grazing in the same field. Which relationship does this example illustrate?

A. parasitism
B. predation
C. commensalism
D. interspecific Competition

Use the following information to answer question 17.

Factors that Affect the Distribution and Population Size of Organisms

1. light intensity
2. porosity
3. annual rainfall
4. emigration
5. pH
6. reproduction
7. mortality
8. population density
9. natality
10. relative humidity
11. competition

17. Classify each factor as a climatic, edaphic, or biotic component of the environment.

A.

Climatic	Edaphic	Biotic
1, 3, 10	2, 5	4, 6, 7, 8, 9, 11

B.

Climatic	Edaphic	Biotic
1, 3, 10	2, 4, 6	5, 7, 8, 9, 11

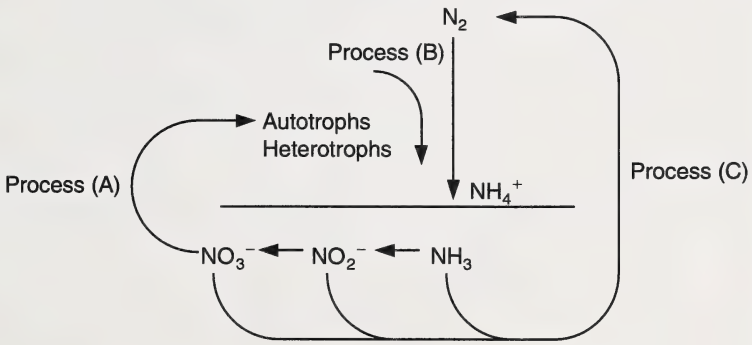
C.

Climatic	Edaphic	Biotic
1, 2, 10	4, 7, 11	3, 5, 6, 8, 9

D.

Climatic	Edaphic	Biotic
1, 2, 10	5, 7	3, 4, 6, 8, 9, 11

Use the following information to answer question 18.

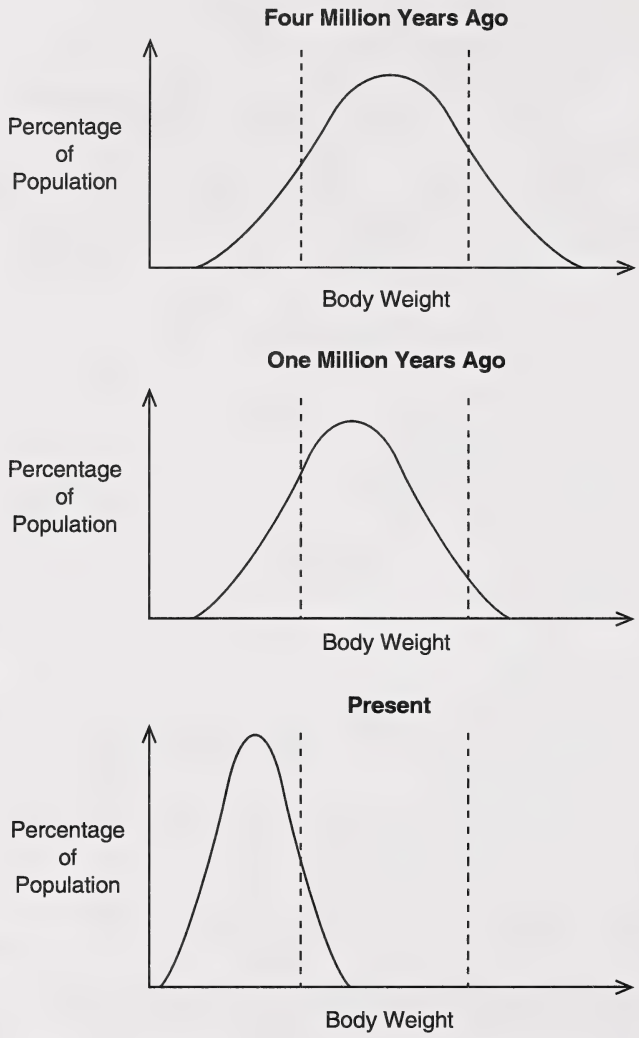


18. What processes do the arrows marked A and B represent?

A. nitrogen fixation and ammonification respectively
B. ammonification and denitrification respectively
C. denitrification and synthesis respectively
D. synthesis and nitrogen fixation respectively

Use the following information to answer questions 19 and 20.

EVOLUTION OF THE CHEETAH'S BODY WEIGHT OVER A FOUR-MILLION-YEAR PERIOD*



* The data represented in the graphs were taken from fossil records and present-day specimens.

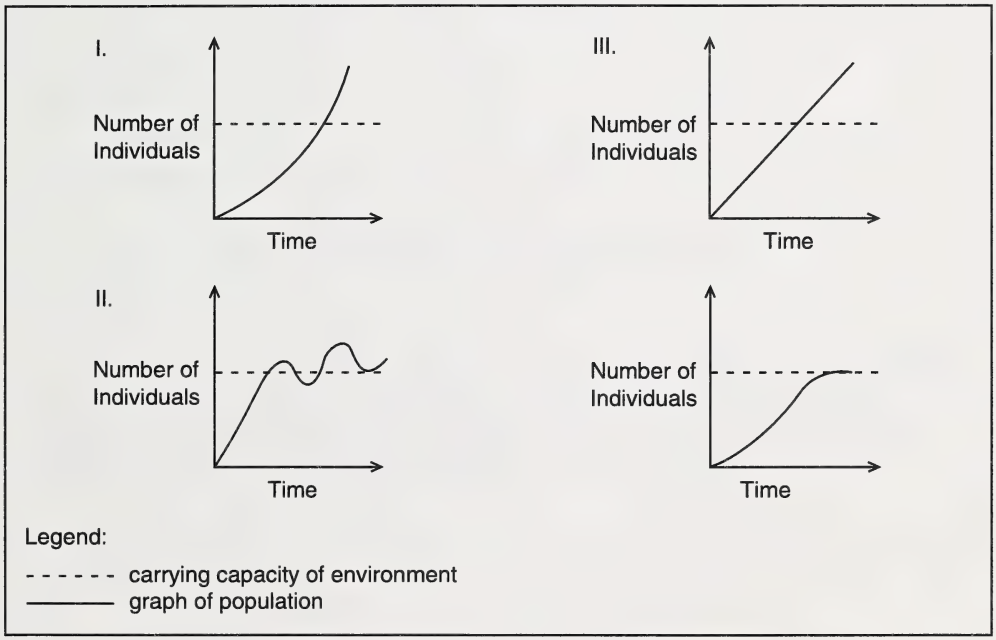
19. Compared to its ancester, the weight of the present-day cheetah

A. shows no significant change
B. shows greater variability
C. shows an average decrease
D. shows an average increase

20. The most significant agent of selection that determines the cheetah's body weight is its ability to

A. catch prey
B. evade predators
C. find mates
D. produce many offspring

Use the following information to answer questions 21 and 22.



21. Which graph best illustrates the population of a natural environment?

A. I
B. II
C. III
D. IV

22. Which graph best illustrates the type of population growth expected in an environment of ideal conditions with no limiting factors?

A. I
B. II
C. III
D. IV

Use this chart to answer questions 23 to 25. This chart shows plant and animal counts over five years in a certain area.

	Plant 1	Plant 2	Plant 3	Animal X	Animal Y	Animal Z
1970	10	75	10	5	0	15
1971	15	52	11	1	2	12
1972	35	27	12	8	6	2
1973	47	8	11	27	15	0
1974	65	2	13	2	50	0

23. For which organism has the carrying capacity been reached?

A. Plant 1
B. Plant 3
C. Animal X
D. Animal Z

24. Which of the following plants will probably be the dominant form in a climax community?

A. Plant 1
B. Plant 2
C. Plant 3
D. impossible to determine

25. Which organism was probably introduced to the community?

A. Plant 1
B. Animal Z
C. Animal X
D. Animal Y

26. Which of the following situations represents conditions which will result in secondary succession?

A. Lichens grow on a rocky area in a forest.
B. A fire sweeps through a northern boreal forest.
C. Grasses become established on sand dunes.
D. A glacial lake shows the growth of sphagnum moss along its margins.

27. Which concentration describes the most dilute solution of lead(II) nitrate, $Pb(NO_3)_{2(aq)}$?

A. 10% by mass
B. 1.0 mol/L
C. 1.0 ppm
D. 1.0 ppb

28. If you were going to dilute a concentrated hydrochloric acid solution to produce 0.200 mol/L $HCl_{(aq)}$, you would NOT need to use a

A. balance
B. pipette
C. volumetric flask
D. standard solution

Use the following information to answer question 29.

Caterpillars ⟶ Small Birds ⟶ Hawks

To kill the caterpillars on a tree, they may be sprayed with a pesticide. As small birds feed on these caterpillars, the concentration of toxins is increased by biological magnification. Let us assume that 20% of the toxin is transferred from organism to organism. A bird eats 200 caterpillars and each hawk eats 4 birds.

29. If each caterpillar contains 7.00×10^{-16} ppm of poison, what will be the concentration of poison in each hawk?

A. 2.80×10^{-14} ppm
B. 2.24×10^{-14} ppm
C. 1.12×10^{-13} ppm
D. 5.6×10^{-13} ppm

30. The fertilizers placed on lawns are usually in solid form. For the grass to be able to absorb the fertilizer, the chemicals must

A. be mixed into the soil
B. be applied on a sunny day
C. be dissolved in water in the soil
D. be applied with a fertilizer spreader

Use the following information to answer question 31.

A 4-L pail was almost filled with water. Sodium chloride was then added to produce a saturated solution with excess salt on the bottom. Several classes obtained 10.0 mL samples, evaporated them to dryness, and recorded their results. Later in the week, the pail was half full and still possessed an excess of salt on the bottom. More students did the same experiment and obtained the same results.

31. This could be explained in the following way:

A. The solution was at equilibrium.
B. The first classes did not measure correctly.
C. The concentration should have increased with time.
D. The technician should have added more salt and water daily.

Use the following information to answer question 32.
Students performed the following diagnostic test and recorded their evidence.

	Red Litmus	Blue Litmus	Conductivity
Solution I	blue	blue	yes
Solution II	red	blue	no
Solution III	red	blue	yes
Solution IV	red	red	yes

32. Which solution is most likely an acid?

A. Solution IV
B. Solution II
C. Solution I
D. Solution III

Use the following compounds to answer questions 33 to 35.

I. $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$

II. $CH_3 - CH_2 - CH = CH_2$

III. $CH_3 - CH(CH_3) - C \equiv CH$

33. Which process is used to change compound I to II?

A. hydrogenation
B. catalytic cracking
C. fractional distillation
D. addition reaction

34. The correct name of the compound III is

A. 3-methyl-4-butyne
B. 2-methyl-4-butyne
C. 3-methyl-1-butyne
D. 3-methyl-2-butyne

35. Which compound(s) will undergo a substitution reaction?

A. II and III
B. I only
C. II only
D. III only

Use the following compounds to answer questions 36 and 37.

I. $CH_2 = CH_2$

II. $CH_3 - CH = CH - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$

III. $CH_3 - C \equiv CH$

IV. $CH_3 - CH = CH_2$

V. $CH_3 - \underset{\displaystyle CH_3 - CH_2 - CH_2}{\underset{|}{CH}} - \underset{\displaystyle CH_2 - CH_3}{\underset{|}{CH}} - CH_3$

36. Which compound(s) belong to the homologous series with C_nH_{2n} as the general formula?

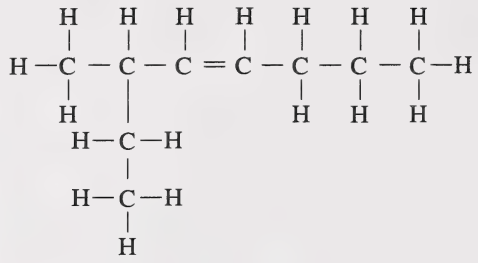
A. III only
B. V only
C. I, II, and IV
D. I, II, III, and IV

37. Which compound(s) will undergo hydrogenation?

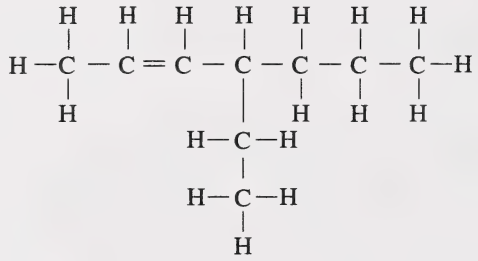
A. V only
B. III only
C. I, II, and IV
D. I, II, III, and IV

38. Structural formulas are necessary when considering organic compounds because several isomers exist for many molecular formulas. The structural diagram that represents the compound 3-methyl-4-octyne is

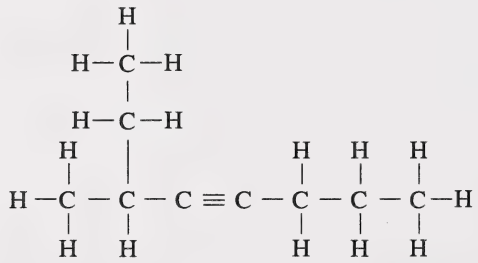
A.



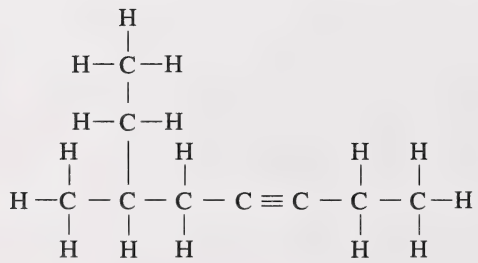
B.



C.



D.



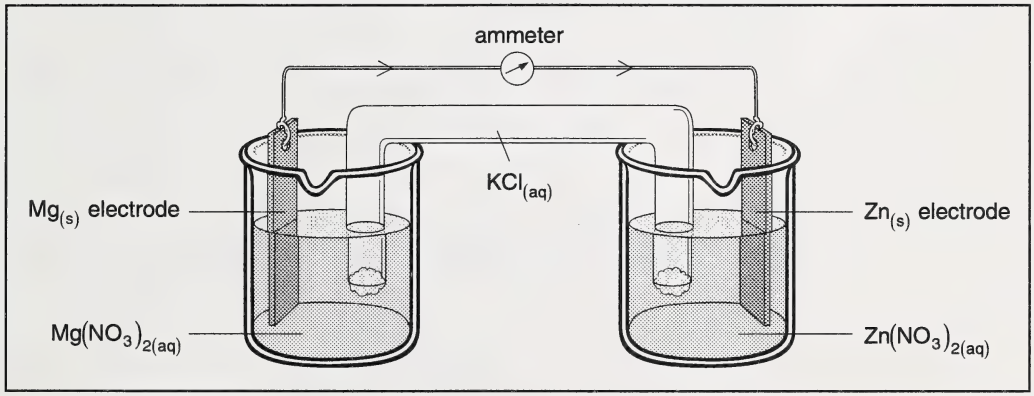
39. The following electrochemical cell was constructed.

$Ag_{(s)} / Ag^{+}_{(aq)} // Cu_{(s)} / Cu^{2+}_{(aq)}$

It was observed that the $Cu_{(s)}$ electrode

A. lost mass
B. gained mass
C. changed to a blue colour
D. changed to a silvery colour

Use the following diagram to answer questions 40 and 41.



40. Which statement best accounts for the direction of electron flow?

A. Zinc gives up electrons forming zinc ions.
B. Zinc ions lose electrons to form solid zinc.
C. Magnesium gives up electrons forming magnesium ions.
D. Magnesium ions lose electrons to form solid magnesium.

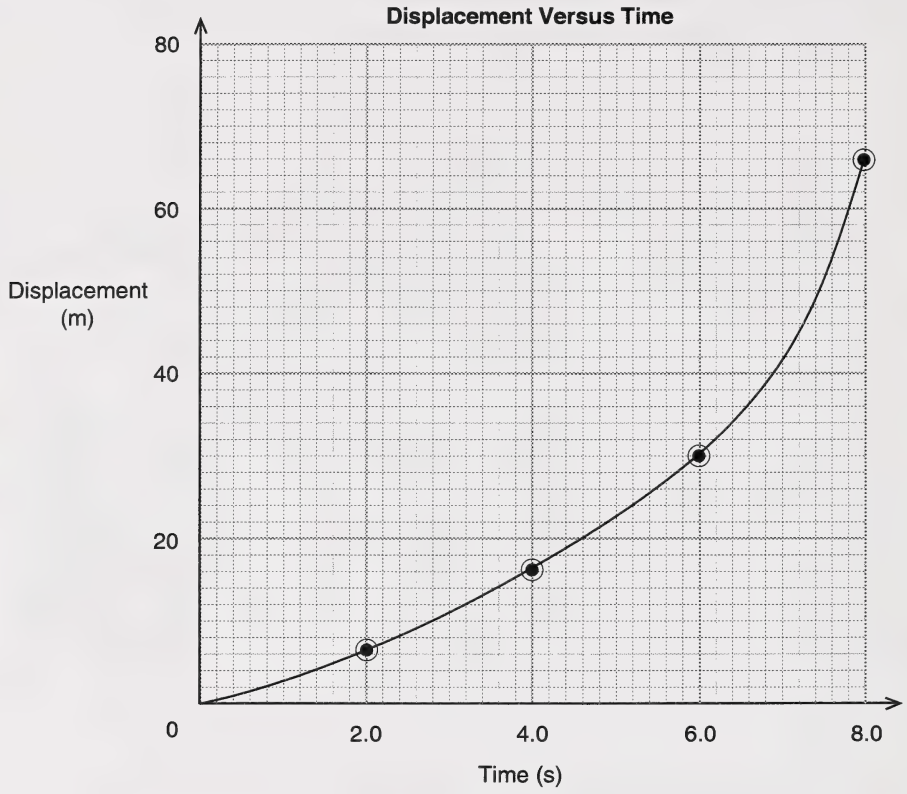
41. Which of the following statements is correct?

A. The zinc electrode is the cathode.
B. Oxidation occurs at the zinc electrode.
C. The magnesium electrode is the cathode.
D. Reduction occurs at the magnesium electrode.

42. Displacement refers to

A. a distance travelled in a specific direction
B. two objects switching positions
C. the total distance travelled
D. the direction of travel

Use the following graph to answer questions 43 to 45.



43. Which type of motion does the graph represent?

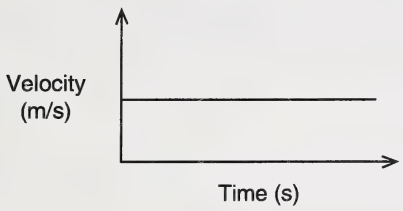
A. constant motion
B. uniformly accelerated motion
C. nonuniformly accelerated motion
D. uniformly decelerating motion

44. The average velocity between $t=3.0$ s and $t=7.0$ s is about

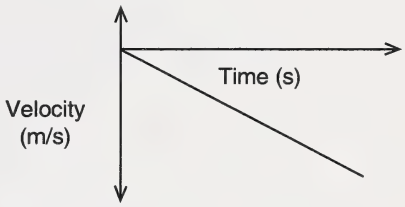
A. 7.8 m/s
B. 31 m/s
C. 4.4 m/s
D. 2.3 m/s

45. Which of the following best illustrates a sketch of a velocity-time graph for the motion illustrated in the previous graph?

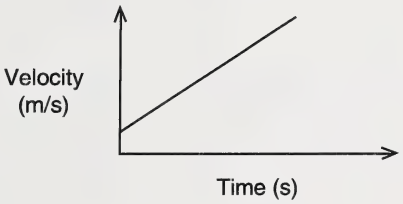
A.



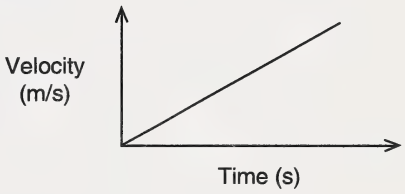
C.



B.



D.



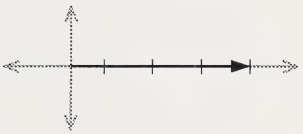
46. A person can swim at 1.0 m/s. A river flows at 4.0 m/s, east. The scale drawing which shows the resultant velocity of a person heading upstream (against the flow of the river) is

A.

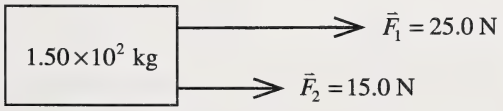
C.

B.

D.



47. Two forces act on a 150 kg block as shown in the diagram. Assuming there is no friction, what is the acceleration of the block?



A. $2.5\ \mathrm{m/s^2}$

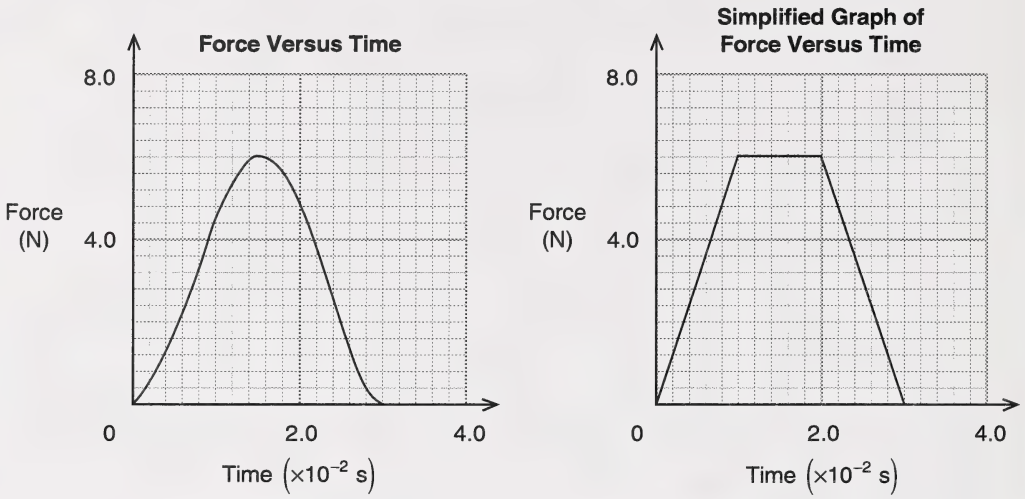
B. $6.1\times10^{-2}\ \mathrm{m/s^2}$

C. $1.7\times10^{-1}\ \mathrm{m/s^2}$

D. $2.7\times10^{-1}\ \mathrm{m/s^2}$

Use the following information to answer question 48.

The force applied to a racquetball changes in a non-linear fashion during the time it is applied. As shown, it is possible to approximate the force applied.



48. The total change in momentum over the entire collision time is

    A. $1.8\ kg \bullet m/s$
    B. $0.90\ kg \bullet m/s$
    C. $0.12\ kg \bullet m/s$
    D. $0.5\ kg \bullet m/s$

49. A 950 kg car travelling east at 65.00 km/h slams into a 2500 kg stationary truck. If the two vehicles remain locked together, what is the resultant velocity of the wreckage immediately after the collision?

    A. 17.9 km/h, east
    B. 24.7 km/h, west
    C. 17.9 km/h, west
    D. 24.7 km/h, east

50. The direction of centripetal force is

    A. toward the centre of rotation
    B. away from the centre of rotation
    C. the same as the direction of the rotation
    D. perpendicular to the line from the object to the centre of rotation

51. Two satellites of different masses orbit the Earth. If the two satellites are each in a geostationary orbit, the two satellites orbit at

A. different orbital speeds, but the same height above the Earth
B. the same orbital speed, but different heights above the Earth
C. the same orbital speed and the same height above the Earth
D. different orbital speeds and different heights above the Earth

52. Studies have shown that the number and severity of injuries sustained in low speed collisions (20 km/h to 30 km/h) is greatly reduced with the installation of airbags and collapsible bumpers to motor vehicles. Airbags and collapsible bumpers reduce the amount of force experienced during a collision by

A. increasing impact time to reduce impact force
B. decreasing impact time to reduce impact velocity
C. increasing impact distance to reduce impact velocity
D. decreasing impact time to reduce impact force

53. Two people pull (horizontally) in opposite directions on a 25 kg sled resting on an icy road. If they each exert forces of 90 N and 92 N respectively, what is the magnitude of the sled's acceleration in the direction of the larger force?

A. $50\ m/s^2$
B. $0.08\ m/s^2$
C. $3.7\ m/s^2$
D. $13\ m/s^2$

54. During road hazard tests, it is found that a luxury car (mass of 1800 kg) can decelerate at $5.5\ m/s^2$ without skidding. What is the force applied by the brakes during such a deceleration?

A. $3.3\times10^2\ N$
B. $9.9\times10^3\ N$
C. $-9.9\times10^3\ N$
D. $-3.3\times10^2\ N$

55. The ability of an object to resist changes in its state of motion is a fundamental property of all matter. This property is called

A. force
B. inertia
C. momentum
D. displacement

PART A – RESPONSE PAGE

1. _____	15. _____	30. _____	44. _____
2. _____	16. _____	31. _____	45. _____
3. _____	17. _____	32. _____	46. _____
4. _____	18. _____	33. _____	47. _____
5. _____	19. _____	34. _____	48. _____
6. _____	20. _____	35. _____	49. _____
7. _____	21. _____	36. _____	50. _____
8. _____	22. _____	37. _____	51. _____
9. _____	23. _____	38. _____	52. _____
10. _____	24. _____	39. _____	53. _____
11. _____	25. _____	40. _____	54. _____
12. _____	26. _____	41. _____	55. _____
13. _____	27. _____	42. _____	
14. _____	29. _____	43. _____	

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Value

35

PART B: WRITTEN RESPONSE

Answer each of the following questions in the space provided after each question.

For full marks, your answers must show all pertinent explanations, calculations, and equations.

Your answers should be presented in a well-organized manner using complete sentences for a written response, and correct units and significant digits for a numerical response.

1. Provide a counterpoint argument for each of the following points made in a debate about global warming.

(2) a. Society should not change their lifestyles and spend money to lower greenhouse gas emissions because there is no conclusive proof that the increase in these gasses in the atmosphere has altered the climate.

(2) b. Society does not need to worry about the potential devastation global warming would have on the planet. If problems begin to occur, society can always adapt and/or fix them.

(3) 2. Your job is to present arguments to the Government of Alberta for funding to support paleontological research. Describe one economical, one social, and one environmental way in which paleontological research has already benefitted or could benefit the province.

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(1)

3. a. Prairie chickens were newly introduced into a county in southeastern Alberta during the late 1970's. A count made on July 1, 1980, revealed a population of 80. On July 1, 1981, there were 92 prairie chickens. (Note: The increase in population already includes the calculation of births and deaths.)

Calculate the percent increase in population using the following equation. Show your work.

$$\%\ \text{population increase} = \frac{\text{increase in population} \times 100}{\text{total initial population}}$$

(3)

b. Assume that the population growth is the same year after year. Calculate the population size for the next ten years. Round to the nearest whole number after each calculation.

Year	Number of Prairie Chickens	Year	Number of Prairie Chickens
1981	92	1986	
1982		1987	
1983		1988	
1984		1989	
1985		1990	

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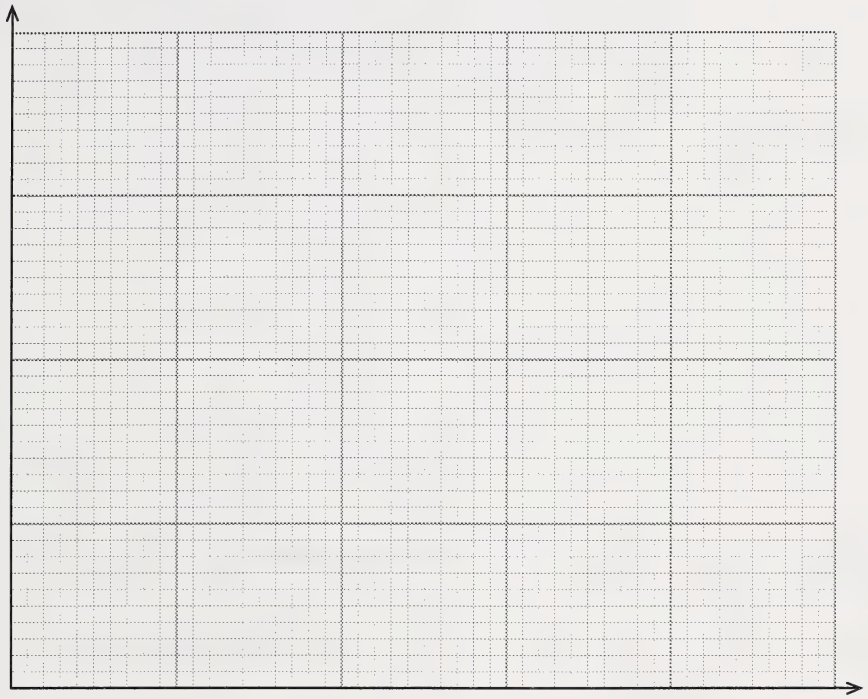
Graph the data you have generated. Label the axes appropriately.



(1) c. Predict what will happen to the prairie chicken population over the next ten years (1991 to 2000).

_____

(2) d. Describe how environmental factors will affect the prairie chicken population in the way that you predicted (in the previous question).

_____

_____

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Name of School _____	Date _____

4. There are four blood types in the human population: O, A, B, and AB. At present there does not appear to be an advantage to having any one particular blood type. However, imagine a deadly virus, that invades the blood system, suddenly appears in the environment, and the individuals with blood type O are the most resistant to this new pathogen. There is no vaccine or medication that will counteract or kill the virus, and few people that contract the virus survive.

(1) a. What individuals are most fit in this scenario and why?

_____

_____

(1) b. What effect would the virus have on the frequency of blood types in the human population over time?

_____

_____

(1) c. For evolution to occur, there must be selection pressure. What is the selection pressure in this case?

_____

5. A chemical technician needs to determine the mass of ammonia required to react with a nitric acid solution in the production of ammonium nitrate fertilizer. If insufficient ammonia is used, the excess nitric acid will damage plants and soil. Adding excess ammonia is considered too costly.

Answer the following questions if there is 800 L of 15.4 mol/L (concentrated) nitric acid solution. Show all details of your calculation.

(1) a. Write a balanced equation to represent the reaction of ammonia and nitric acid.

Name of Student _____	Student I.D. # _____
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(2) b. Calculate the amount of nitric acid used (in kmol).

(2) c. Calculate the amount of ammonia needed (in kmol).

(2) d. Calculate the mass of ammonia needed (in kg).

(4) 6. Explain the difference between a substitution reaction and an addition reaction with hydrocarbons. Write a chemical equation for each to illustrate the difference.

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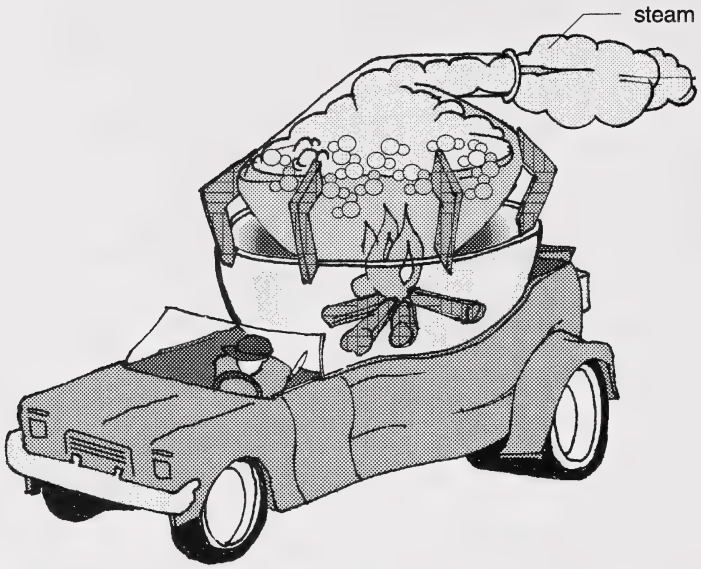
(4)

7. The following diagram depicts a model of an alternate type of vehicle.



Use your knowledge of Newton's Third Law to briefly describe how this vehicle works. Be sure to discuss the action force and reaction force in your description. Why doesn't this vehicle work in practice?

(3)

8. When you jump from a bench to the ground you always bend your knees as your feet touch the ground. Explain the purpose of bending your knees in terms of the impulse formula $\left(\vec{I} = \vec{F}\Delta t\right)$.

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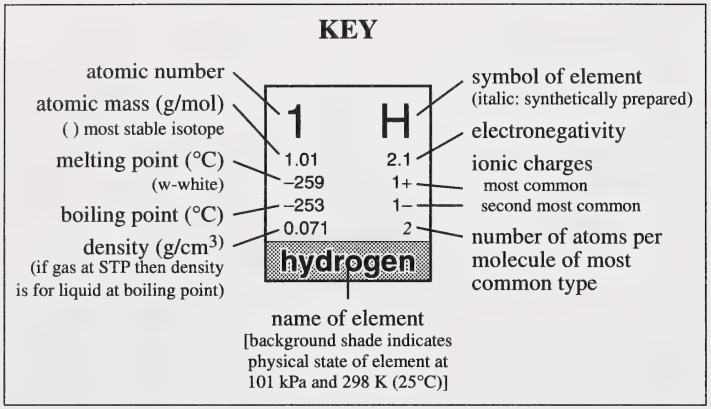
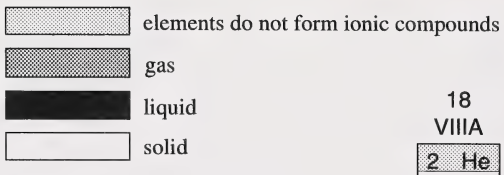
Name of School _____ Date _____

Science 20 Formula Sheet

1. $n = \frac{m}{M}$
2. $C = \frac{n}{V}$
3. $C_1V_1 = C_2V_2$
4. $\vec{d} = \vec{v}t$
5. $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$
6. $\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$
7. $\vec{F} = m\vec{a}$
8. $\vec{F}_g = m\vec{g}$
9. $W = mg$
10. $F_g = \frac{Gm_1m_2}{r^2}$
11. $F_c = \frac{mv^2}{r}$
12. $a = \frac{v^2}{r}$
13. $F_c = \frac{4\pi^2mr}{T^2}$
14. $\vec{p} = m\vec{v}$
15. $\vec{p}_A = -\Delta\vec{p}_B$
16. $m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1{}' + m_2\vec{v}_2{}'$

Periodic Table of Elements





GROUP 1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H 1.01 2.1 –259 1+ –253 1– 0.071 2 hydrogen																	2 He 4.00 – –272 – –269 – 0.126 – helium
3 Li 6.94 1.0 180 1+ 1347 – 0.53 – lithium	4 Be 9.01 1.5 1278 2+ 2970 – 1.85 – beryllium											5 B 10.81 2.0 2079 – 2550 – 2.34 – boron	6 C 12.01 2.5 3550 – 4827 – 2.26 – carbon	7 N 14.01 3.0 –210 3– –196 – 0.81 2 nitrogen	8 O 16.00 3.5 –218 2– –183 – 1.14 2 oxygen	9 F 19.00 4.0 –220 1– –188 – 1.505 2 fluorine	10 Ne 20.18 – –249 – –246 – 1.20 – neon
11 Na 22.99 0.9 97.8 1+ 883 – 0.97 – sodium	12 Mg 24.31 1.2 649 2+ 1090 – 1.74 – magnesium											13 Al 26.98 1.5 660 3+ 2467 – 2.70 – aluminum	14 Si 26.09 1.8 1410 – 2355 – 2.33 – silicon	15 P 30.97 2.1 44.1 w 3– 280 w – 1.82 w 4 phosphorus	16 S 32.06 2.5 113 2– 445 – 2.07 8 sulphur	17 Cl 35.45 3.0 –101 1– –35 – 1.56 2 chlorine	18 Ar 39.95 – –189 – –186 – 1.40 – argon
19 K 39.10 0.8 63.7 1+ 774 – 0.86 – potassium	20 Ca 40.08 1.0 839 2+ 1484 – 1.55 – calcium	21 Sc 44.96 1.3 1541 3+ 2831 – 3.0 – scandium	22 Ti 47.90 1.5 1660 4+ 3287 3+ 4.54 – titanium	23 V 50.94 1.6 1890 5+ 3380 4+ 6.1 – vanadium	24 Cr 52.00 1.6 1857 3+ 2672 2+ 7.19 – chromium	25 Mn 54.94 1.5 1245 2+ 1982 4+ 7.43 – manganese	26 Fe 55.85 1.8 1535 3+ 2750 2+ 7.87 – iron	27 Co 58.93 1.8 1495 2+ 2870 3+ 8.9 – cobalt	28 Ni 58.71 1.8 1453 2+ 2732 3+ 8.9 – nickel	29 Cu 63.55 1.9 1083 2+ 2567 1+ 8.96 – copper	30 Zn 65.38 1.6 420 2+ 907 – 7.13 – zinc	31 Ga 69.74 1.6 29.8 3+ 2403 – 5.90 – gallium	32 Ge 72.59 1.8 937 4+ 2830 – 5.32 – germanium	33 As 74.92 2.0 – 3– 615 – 5.73 – arsenic	34 Se 78.96 2.4 217 2– 685 – 4.79 – selenium	35 Br 79.90 2.8 –7.2 1– 58 – 3.12 2 bromine	36 Kr 83.80 – –157 – –152 – 2.41 – krypton
37 Rb 85.47 0.8 38.9 1+ 688 – 1.53 – rubidium	38 Sr 87.62 1.0 769 2+ 1384 – 2.5 – strontium	39 Y 88.91 1.3 1522 – 3338 – 4.47 – yttrium	40 Zr 91.22 1.4 1852 – 4377 – 6.51 – zirconium	41 Nb 92.91 1.6 2468 – 4742 – 8.6 – niobium	42 Mo 95.94 1.8 2617 – 4612 – 10.2 – molybdenum	43 *Tc* 98.91 1.9 2172 – 4877 – 11.5 – technetium	44 Ru 101.07 2.2 2310 – 3900 – 12.4 – ruthenium	45 Rh 102.91 2.2 1966 – 3727 – 12.4 – rhodium	46 Pd 106.40 2.2 1552 2+ 3140 4+ 12.0 – palladium	47 Ag 107.87 1.9 962 1+ 2212 – 10.5 – silver	48 Cd 112.41 1.7 321 2+ 765 – 8.65 – cadmium	49 In 114.82 1.7 157 3+ 2080 – 7.31 – indium	50 Sn 118.69 1.8 232 4+ 2270 2+ 7.31 – tin	51 Sb 121.75 1.9 631 3+ 1750 5+ 6.70 – antimony	52 Te 127.60 2.1 450 2– 990 – 6.24 – tellurium	53 I 126.90 2.5 114 1– 184 – 4.93 2 iodine	54 Xe 131.30 – –107 – –108 – 3.52 – xenon
55 Cs 132.91 0.7 28.4 1+ 678 – 1.90 – cesium	56 Ba 137.33 0.9 725 2+ 1640 – 3.5 – barium	57 La 138.91 1.1 921 – 3457 – 6.15 – lanthanum	72 Hf 178.49 1.3 2227 – 4602 – 13.3 – hafnium	73 Ta 180.95 1.5 2996 – 5425 – 16.7 – tantalum	74 W 183.85 1.7 3410 – 5660 – 19.3 – tungsten	75 Re 186.21 1.9 3180 – 5627 – 21.0 – rhenium	76 Os 190.20 2.2 3045 – 5027 – 22.6 – osmium	77 Ir 192.22 2.2 2410 – 4130 – 22.5 – iridium	78 Pt 195.09 2.2 1772 4+ 3827 2+ 21.5 – platinum	79 Au 196.97 2.4 1064 3+ 2807 1+ 19.3 – gold	80 Hg –39.0 2+ 357 1+ 13.6 – mercury	81 Tl 204.37 1.8 304 1+ 1457 3+ 11.85 – thallium	82 Pb 207.19 1.8 328 2+ 1740 4+ 11.4 – lead	83 Bi 208.98 1.9 271 3+ 1560 5+ 9.8 – bismuth	84 Po (209) 2.0 254 2+ 962 4+ (9.2) – polonium	85 At (210) 2.2 302 1– 373 – – 2 astatine	86 Rn (222) – –71 – –62 – 4.4 – radon
87 Fr (223) 0.7 (27) 1+ (677) – 2.4 – francium	88 Ra 226.03 0.9 700 2+ 1140 – 5.0 – radium	89 Ac (227) 1.1 1050 3+ 3200 – 10.07 – actinium	104 Unq (261) unnilquadium	105 Unp (262) unnilpentium	106 Unh (263) unnilhexium	107 Uns (262) unnilseptium		109 Une (266) unnilennium									

58 Ce 140.12 1.1 799 3+ 3426 – 6.67 – cerium	59 Pr 140.91 1.1 931 3+ 3512 – 6.77 – praseodymium	60 Nd 144.24 1.2 1021 3+ 3068 – 7.00 – neodymium	61 *Pm* (145) – 1080 3+ 2460 – 7.22 – promethium	62 Sm 150.35 1.2 1077 3+ 1791 – 7.52 – samarium	63 Eu 151.96 – 822 3+ 1597 2+ 5.24 – europium	64 Gd 157.25 1.1 1313 3+ 3266 – 7.90 – gadolinium	65 Tb 158.93 1.2 1356 3+ 3123 – 8.23 – terbium	66 Dy 162.50 – 1412 3+ 2562 – 8.55 – dysprosium	67 Ho 164.93 1.2 1474 3+ 2695 – 8.80 – holmium	68 Er 167.26 1.2 159 3+ 2863 – 9.07 – erbium	69 Tm 168.93 1.2 1545 3+ 1947 – 9.32 – thulium	70 Yb 173.04 1.1 819 3+ 1194 – 6.97 – ytterbium	71 Lu 174.97 1.2 1663 3+ 3395 – 9.84 – lutetium
90 Th 232.04 1.3 1750 4+ 4790 – 11.7 – thorium	91 Pa 231.04 1.5 <1600 5+ – – 15.4 – protactinium	92 U 238.03 1.7 1132 6+ 3818 4+ 19.1 – uranium	93 *Np* 237.05 1.3 640 5+ 3902 – 19.5 – neptunium	94 *Pu* (244) 1.3 641 4+ 3232 6+ – – plutonium	95 *Am* (243) 1.3 994 3+ 2607 – 13.7 – americium	96 *Cm* (247) – 1340 3+ – – – – curium	97 *Bk* (247) – – 3+ – – 14 – berkelium	98 *Cf* (251) – – 3+ – – – – californium	99 *Es* (254) – – – – – – – einsteinium	100 *Fm* (257) – – – – – – – fermium	101 *Md* (256) – – – – – – – mendelevium	102 *No* (259) – – – – – – – nobelium	103 *Lr* (257) – – – – – – – lawrencium

Solubility of Ionic Compounds in Water

Ion	Cl^- Br^- I^-	S^{2-}	OH^-	SO_4^{2-}	CO_3^{2-} PO_4^{3-} SO_3^{2-}	CH_3COO^-	NO_3^-	NH_4^+
High solubility	Most	Group 1 Group 2	Group 1 Sr^{2+} Ba^{2+}	Most	Group 1	Most	All	All
Low solubility	Ag^+ Pb^{2+} Cu^+ Hg_2^{2+}	Most	Most	Ag^+ Pb^{2+} Ca^{2+} Ba^{2+} Sr^{2+} Ra^{2+}	Most	Ag^+	None	None

Colour Chart of Common Aqueous Ions

Ion	Symbol	Colour
chromate	CrO_4^{2-}	yellow
chromium(III)	Cr^{3+}	green
chromium(II)	Cr^{2+}	blue
cobalt(II)	Co^{2+}	pink
copper(I)	Cu^+	green
copper(II)	Cu^{2+}	blue
dichromate	$Cr_2O_7^{2-}$	orange
iron(II)	Fe^{2+}	pale green
iron(III)	Fe^{3+}	pale yellow
manganese(II)	Mn^{2+}	pale pink
permanganate	MnO_4^-	purple

TEACHER QUESTIONNAIRE FOR SCIENCE 20

This is a course designed in a new distance-learning format, so we are interested in your responses. Your constructive comments will be greatly appreciated so that a future revision may incorporate any necessary improvements.

Teacher's Name _____ Area of Expertise _____

School Name _____ Date _____

Design

1. The modules follow a definite systematic design. Did you find it easy to follow?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

2. Did your observations reveal that the students found the design easy to follow?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

3. Did you find the Learning Facilitator's Manual helpful?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

4. Part of the design involves stating the objectives in student terms. Do you feel this helped the students understand what they were going to learn?

   ❑ Yes ❑ No If no, explain.

   _____

   _____

5. The Learning Facilitator's Manual contains Assignment answers and a sample test. Did you find these helpful?

❑ Yes ❑ No If no, explain.

_____

_____

6. Did the Follow-up Activities prove to be helpful?

❑ Yes ❑ No If no, explain.

_____

_____

7. Were students motivated to try these Follow-up Activities?

❑ Yes ❑ No If no, give details.

_____

_____

8. Suggestions for computer and video activities are included in the course. Were your students able to use these activities?

❑ Yes ❑ No Comment on the lines below.

_____

_____

9. Were the assignments appropriate?

❑ Yes ❑ No If no, give details.

_____

_____

10. Did you fax assignments? ❑ Yes ❑ No

11. If you did fax, did you get satisfactory results from using this procedure?

❑ Yes ❑ No If no, give details.

_____

_____

Instruction

1. Did you find the instruction clear?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

2. Did your observations reveal that the students found the instruction interesting?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

3. Did you find the instruction adequate?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

4. Was the reading level appropriate?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

5. Was the work load adequate?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

6. Was the content accurate and current?

   ❑ Yes ❑ No If no, give details.

   _____

   _____

7. Did the content flow consistently and logically?

❑ Yes ❑ No If no, give details.

_____

_____

8. Was the transition between booklets smooth?

❑ Yes ❑ No If no, give details.

_____

_____

9. Was the transition between print and media smooth?

❑ Yes ❑ No If no, give details.

_____

_____

Additional Comments

_____

_____

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_____

Thanks for taking the time to complete this survey. Your feedback is important to us.

Fax Number: 674-6686

Instructional Design and Development Unit
Alberta Distance Learning Centre
Box 4000
Barrhead, Alberta
T0G 2P0

Note: Please ensure that each of your students has completed and forwarded a copy of the Course Survey.

N.L.C./B.N.C.
3 3286 50153 8256

Science 20

Learning Facilitator's Manual

L.R.D.C.
Producer

1994